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FOOD AND HEALTH

An Introduction to the Science of Nutrition

By

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PREFACE

THIS book, which last appeared in 1938, has been almost entirely rewritten in order to make it up to date. The food tables at the end have also been revised, and a good many new tables have been included in the text.

I am much indebted to the following authors and publishers, and to the editors and publishers of the following periodicals for permission to reproduce figures, tables, &c.: *Lessons in Elementary Physiology*, by T. H. Huxley (Macmillan & Co., Ltd.), for Fig. 1; Dr. Du Bois and *The Science of Nutrition*, by G. Lusk (W. B. Saunders Co., Philadelphia), for Fig. 2; *The Journal of Physiology* for Fig. 4; the *British Dental Journal* for Fig. 5; *Report to the Local Government Board on the Nutritive Value of Bread made from Different Varieties of Wheat Flour*, by J. M. Hamill (H.M. Stationery Office), for Fig. 6; *The Nutritive Value of Fruits, Vegetables, and Nuts*, by R. A. McCance, E. M. Widdowson, and L. R. B. Shackleton (H.M. Stationery Office), for Fig. 9 and Tables 6 and 18; *The Amino Acid Composition of Proteins and Foods*, by R. J. Block and D. Bolling (C. C. Thomas, Springfield, Illinois), for the data given in Table 1; *Chemistry of Food and Nutrition*, by H. C. Sherman (The Macmillan Co., New York), for Table 3; *Principles of Nutrition and the Nutritive Value of Food*, by W. O. Atwater (U.S. Dept. of Agriculture), for Table 4; *Recommended Dietary Allowances* (U.S. National Research Council) for Table 9; *The Lancet* for Tables 11 and 12; *The Biochemical Journal* for Table 13; *The Diabetic Life*, by R. D. Lawrence (J. and A. Churchill, Ltd.), for Table 14; *Holt's Diseases of Infancy and Childhood*, by L. E. Holt and R. McIntosh (D. Appleton-Century Co., New York), for Table 16; *Hutchison's Food and the Principles of Dietetics*, by V. H. Mottram and G. Graham (E. Arnold & Co.), for Table 17; *The Chemical Composition of Foods*, by R. A. McCance and E. M. Widdowson (H.M. Stationery Office), for Table 19 and for the protein, fat, carbohydrate, calories, calcium, and iron values in the tables on pp. 158–70; *Modern Dietary Treatment*, by M. Abrahams and E. M. Widdowson (Baillière, Tindall, and Cox), for Table 20; *Nutritive Values of Wartime Foods* (H.M. Stationery Office) for the vitamin A, B_1, C, D, and riboflavin values in the tables on pp. 148–52, 154–6, 158–70; Dr. C. A. Elvehjem and *Tables of Food Composition in Terms of Eleven Nutrients* (U.S. Dept. of Agriculture) for the nicotinic acid values on pp. 153, 158–70.

A. B. C.

CAMBRIDGE, 1946

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CHAPTER I

CHEMISTRY AND NUTRITIVE VALUE

> The Things we eat by various Juice controul
> The Narrowness or Largeness of our Soul.
>
> DR. WILLIAM KING, 1709.

IN these days of world food shortages it becomes more important than ever to know what makes up an adequate diet—a diet which will keep men and women well and strong, and which will sustain the health of children throughout their years of growth. The aim of this book is to give a simplified account of nutrition, with this question always in view.

For this purpose we shall consider food in relation to the needs of the human body.

The Functions of Food

The most obvious function of food is to supply the new material required for growth. Children cannot build up their bodies and increase in weight unless they are provided with food, and even grown-up people also require food for body-building purposes because the body-tissues have to be continually renewed. This process of renewal goes on unobtrusively all through our lives, but it is particularly marked during periods of convalescence.

Although body-building is of supreme importance, it uses up only a small proportion of the food we eat. Another very small proportion is excreted as waste material. The rest of the food remains to be accounted for. Strangely enough, it is used as fuel to provide the energy necessary for muscular movements and other bodily activities. As a result of these activities heat is produced, and this keeps our bodies warm. Every muscular movement, whether voluntary (such as lifting weights or walking) or involuntary (such as the beating of the heart), uses up a certain amount of energy, and this energy is obtained by burning an equivalent amount of the body's supply of fuel. The body fuel consists of carbon-containing compounds which are oxidized (that is, burnt) by the oxygen taken in by the lungs during breathing. We shall see later that different foods provide us with different amounts of energy when they are burnt in the body as fuel.

A further function of food is to provide very small quantities of special substances which are essential for regulating bodily processes. If the diet lacks any of these substances, children do not grow properly, and both children and adults are liable to develop one or other of the so-called deficiency diseases. These diseases are caused by defective diets, and can be prevented by adding to the diet the particular substance that was originally missing. There are several substances of this kind, and foods containing them are sometimes called protective foods, since they protect us against deficiency diseases.

Certain foods serve other purposes in the body, such as assisting in digestion, but these are subsidiary functions. The three main functions of food are body-building, energy-production, and the regulation of bodily processes.

Nutrients

In order to understand which of our foods are body-building and which serve as fuel, it is necessary to consider food not as bread, meat, fruit, &c., but as a mixture of chemical substances. The most important of these chemical constituents of food—proteins, carbohydrates, fats, mineral elements, and vitamins—are known as nutrients. Water is not usually included with the nutrients, although it occurs in many foods and is of vital importance in the body.

Roughly speaking, we can distribute the three main functions of food between the various nutrients in the following way: proteins are the chief body-builders; carbohydrates, fats, and also proteins serve as fuel; mineral elements and vitamins regulate bodily processes. This is, as we have said, a rough classification. To be more exact, we should include in the body-building category certain mineral elements, and also fats and carbohydrates, since they enter to a small extent into the composition of the body-tissues. With fats and carbohydrates, however, such a small proportion is used for body-building that it is convenient to consider these substances merely as fuel foods.

Proteins, carbohydrates, and fats occur in food in far larger amounts than either mineral elements or vitamins, and we shall therefore deal with them first. Most foods contain more than one of these nutrients, but often one is predominant. For instance, fat is predominant in butter and dripping, carbohydrate is predominant in cereals, vegetables, and fruit, and protein in lean meat and white fish.

Proteins

Proteins are exceedingly complicated compounds, containing carbon, hydrogen, oxygen, nitrogen, and usually sulphur; phosphorus is also present in a few proteins, such as casein, the chief protein of milk. Proteins, like carbohydrates and fats, can be used in the body as fuel, but their most important function is body-building. The great bulk of the body-building is done by proteins. Children need proteins to maintain growth, and both children and adults need them for the renewal of bodily tissues. Neither fats nor carbohydrates are of direct value for this purpose because they contain no nitrogen. Practically all the tissues of the body contain nitrogen, and indeed the solid part of our flesh is largely composed of proteins, which are not unlike the proteins of our food.

Healthy adults are said to be in a state of nitrogen equilibrium, because the amount of nitrogen they gain from the proteins of their food is equal to the amount of nitrogen they lose by excretion (this nitrogen is one of the constituents of urea, which occurs in urine). If extra protein is added to the diet, there will accordingly be an extra excretion of nitrogen. On the other hand, if the amount of protein is cut down within reasonable limits, less nitrogen will be excreted. If the protein is cut down to starvation level, however, nitrogen equilibrium can no longer be maintained; urea is still excreted, but the nitrogen it contains has to be provided from the body-tissues themselves, since there is not enough protein in the diet. To prevent this wasting away of the flesh it is necessary to have a daily allowance of protein to act as a source of nitrogen. After the removal of the nitrogenous part of the protein, the remainder is burnt in the body as fuel.

There are a number of different proteins in our food but they have certain features in common. Each protein consists of a collection of slightly simpler substances, called amino-acids, grouped together in a special way. About twenty different amino-acids have so far been discovered in the proteins of animals and plants. Some of these are relatively simple compounds in which the atoms of the molecule are arranged in a more or less straight chain. For instance, glycine, the simplest of the amino-acids, has the formula CH_2NH_2COOH. Certain other amino-acids, however, contain complex rings of atoms in addition to a straight chain. The amino-acids occur in varying amounts in different proteins; most food proteins contain a good many, and some contain all the twenty or so naturally occurring amino-acids that are yet known.

Proteins are not all of equal value as food because they do not all contain the amino-acids we require. About half of the amino-acids necessary for the formation of our body proteins can be manufactured in the body from suitable materials. But there are ten amino-acids which the body needs and cannot manufacture. These 'essential' amino-acids, as they are called, have to be obtained ready-made from the proteins of our food. Proteins that are richly supplied with the essential amino-acids are obviously more useful as food than those that are not. The nutritive value of a protein thus depends on the amino-acids it contains.

Generally speaking, proteins from animal products (eggs, milk, cheese, meat, and fish) are superior to those from plant products (cereals, nuts, vegetables, and fruits). For this reason, animal proteins are sometimes said to be first-class and plant proteins second-class. But this distinction is by no means clear cut. Thus, green leaves contain a small amount of protein of remarkably good quality; on the other hand, gelatin which is a derived protein from animal sources, is of very poor quality (see Table 1, p. 6). Moreover, as we shall see in a moment, there is not much point in making a distinction of this kind because it is possible to take two second-class proteins together and obtain a first-class mixture. Here, in spite of the proverb, two blacks can make one white.

One way of measuring the relative value of different proteins is to carry out feeding experiments, either on animals or on man. The object is to find out how much of a given protein will 'spare' a definite amount of body protein. The results of such experiments are expressed as 'biological values', the maximum being taken as 100. According to the original definition, a protein with a biological value of 100 is one that spares its own weight of body protein; one that spares half its own weight of body protein has a biological value of 50, and so on. Experiments of this kind have shown that, as we have said, some proteins act as supplements to one another, in which case the biological value of the mixture is far greater than would be expected from the two separate values. For instance, in an experiment with rats (which resemble human beings in many ways dietetically) it was found that cheese protein had a far higher biological value than bread protein, if the foods were eaten separately on alternate days; but if the bread and cheese were eaten together, the biological value of the mixture of proteins was as high as that of the cheese protein alone. In another experiment with rats it was found that the protein of potatoes had a low biological value and that of milk a high one; but when milk and potatoes were eaten together, the biological value of the mixture of proteins was nearly as high as that of the milk protein alone. Here again there was no supplementary effect when the foods were eaten separately on alternate days—an argument in favour of a well-mixed diet.

Another way of assessing the value of proteins is to find out how much of each essential amino-acid they contain. Unfortunately our knowledge of protein chemistry is still far from complete. Further research is necessary before satisfactory values can be given, but some tentative values are included in Table 1, together with suggested daily allowances for adults. It can be seen from the table that the whole of the ten suggested allowances could be obtained from

TABLE 1. *The Nutritive Value of some Proteins in Terms of Amino-acids*

	Arginine	*Histidine*	*Lysine*	*Tryptophane*	*Phenylalanine*	*Cystine*[1]	*Methionine*	*Threonine*	*Leucine*	*Isoleucine*	*Valine*	*Total percentages of essential amino-acids*
Egg protein: white .	**5·8**	**2·2**	**6·5**	**1·6**	**5·5**	**2·3**	**4·4**	**4·9**[2]	**19·0**[2]	**5·3**[2]	**4·4**[2]	62
yolk .	**8·2**	**2·6**	**5·5**	**1·6**	**5·7**	**1·9**	**2·5**					
Milk protein . .	**4·3**	**2·5**	**7·5**	**1·6**	**5·7**	**1·2**	**2·8**	**4·6**	**12·1**[3]	**6·5**[3]	**7·0**[3]	56
Meat muscle protein .	**7·2**	**2·1**	**7·6**	**1·2**	**4·5**	**1·1**	**3·2**	**5·3**	**12·1**	**3·4**	3·4	51
Fish muscle protein[4] .	**5·6**	1·9	**6·8**	**1·3**	**4·5**	**1·2**	**3·4**	**4·4**				
Gelatin . . .	**7·6**	1·0	4·3	0	2·0	0·1	0·8	1·5	3·7	1·7	2·5	25
Leaf protein . .	**6·6**	1·4	5·0	**2·1**	**4·5**	**1·8**	**2·3**	**4·8**	**11·0**	**5·4**	**6·0**	51
Oat protein . .	**6·0**	**2·0**	3·3	**1·3**	**6·9**	**1·8**	**2·3**	**3·5**	8·0	**5·3**	**6·5**	47
Rice protein . .	**7·2**	1·5	3·2	**1·3**	**6·3**	**1·3**	**3·4**	**3·9**	7·7	**5·1**	**6·4**	47
Soya-bean protein .	**5·8**	**2·3**	**5·4**	**1·6**	**5·7**	0·6	2·0	**4·0**	6·6	**4·7**	**4·2**	43
White flour protein .	**3·9**	**2·2**	1·9	0·8	**5·5**	**1·9**	**3·0**	2·7	**12·0**	**3·7**	3·4	41
Wheat-germ protein .	**6·0**	**2·5**	**5·5**	1·0	4·2	0·6	2·0	**3·8**	7·4	3·0	**4·1**	40
Suggested daily allowances, for adults, of amino-acids in gm..	3·5	2·0	5·2	1·1	4·4	3·8		3·5	9·1	3·3	3·8	

[1] Cystine is not essential, but it is bracketed with methionine because methionine can be produced from cystine in the body.

[2] These values refer to whole egg.

[3] These values refer to casein only, not to the mixed proteins of whole milk.

[4] Values for leucine, isoleucine, and valine are as yet uncertain.

This table gives the approximate percentage of the essential amino-acids in some proteins, together with suggested daily allowances of amino-acids. The amino-acid value is printed in heavy type if the suggested daily allowance can be obtained from 100 grammes of the protein containing it. If the value falls below this, it is printed in ordinary type. [Compiled from results given in *The Amino Acid Composition of Proteins and Foods*, by R. J. Block and D. Bolling (Charles C. Thomas), 1945.]

100 grammes of protein from either eggs or milk. In order to emphasize this point, these values are printed in heavy type. With meat, 100 grammes of protein would supply nine of the ten suggested allowances, and this is probably true of fish protein as well. When we come to gelatin, however, we find that only one of the suggested allowances could be met out of 100 grammes; all the other nine essential amino-acids are poorly represented. With plants, the proteins of leaves and oats head the list, both having only two essential amino-acids in short supply; and the proteins of rice and soya bean come next with three. The protein of white flour is weak in four essential amino-acids, three of which are found in greater abundance in wheat-germ protein. If we consider the total amount of essential amino-acids (see the last column in Table 1) we find that in eggs this makes up about 62 per cent. of the weight of the protein, the remaining 38 per cent. being made up of unessential amino-acids. Next come milk protein with 56 per cent. of essential amino-acids and meat protein with 51 per cent. On this basis, leaf protein is equal to meat protein, but the other plant proteins are not quite so good.

If we turn now from the quality of proteins to the quantity, we find that animal products usually contain far more than plant products. Most cheese contains about 25 per cent. of protein, most cooked meat 20–30 per cent., most cooked fish 15–25 per cent., fresh eggs 12 per cent., dried eggs 43 per cent., fresh milk 3·3 per cent., and dried skim ('household') milk 34 per cent. The richest protein foods of plant origin are seeds and seed products: soya-bean flour (full fat) has nearly as much protein as dried eggs, namely 40 per cent., and most nuts have a large amount, notably peanuts with 28 per cent. and almonds with 20 per cent.; chestnuts, however, have only 2 per cent. All these values refer to the edible portion only. Flour has 8–13 per cent. of protein, bread about 8 per cent., and biscuits 6–11 per cent.; dried legumes (peas, beans, and lentils) have about 21 per cent. when dry, and about 7 per cent. after being soaked and cooked. But other plant products contain only small amounts of protein; boiled potatoes have about 1·5 per cent., and most other vegetables, raw or cooked, have between 0·5 and 5 per cent.; fresh fruits contain less still, and even dried fruits (in the dry state) have only 2–5 per cent.

The amount of protein in a number of foods is given in the tables on pages 158 to 170. It will be seen that the values are expressed not as percentages, but as the number of grammes of protein per ounce of food. This odd mixture of grammes and ounces has been adopted because it is extremely useful in calculations of the food value of diets. Admittedly the percentage composition gives the best mental picture of a food. We feel, for instance, that we know something about the chemical nature of a boiled egg if we are told that it contains 11·9 per cent. of protein and 12·3 per cent. of fat. But if we eat a boiled egg and want to know how much of these nutrients we have obtained, we shall find that it is far more useful to know that every ounce of boiled egg contains 3·4 grammes of protein and 3·5 grammes of fat; if we merely multiply these numbers by the weight of the egg in ounces, we can then obtain a figure for the amount of protein and fat we have actually eaten. If the boiled egg weighed 2 ounces, this works out at 6·8 grammes of protein and 7 grammes of fat. In this country it is best to deal with food for diets in ounces and not in grammes, because we are more familiar with ounces. Most of us know how much bread, butter, and so on make up an ounce, and if not we can easily weigh out a 1-ounce portion and see how large it is. On the other hand, the nutrients (protein, &c.) are best expressed by the metric system, because they are universal in their application and not subject to local conditions as foods themselves are.

Carbohydrates

Having discussed the proteins, we can now consider the carbohydrates and fats, both of which are used in the body as fuel or for storage purposes. The carbohydrates, as the name implies, are made up of carbon, hydrogen, and oxygen, the two latter being in the same proportion as in water, that is, two atoms of hydrogen to one of oxygen. The carbohydrates in our food belong to three different sections of the carbohydrate group, namely, the simple sugars or monosaccharides, the compound sugars or disaccharides, and the polysaccharides (starches, &c.).

The simple sugars (monosaccharides) that are of most importance in food are glucose, fructose, and galactose. These three sugars are all very similar in chemical composition, and all have the chemical formula $C_6H_{12}O_6$. The compound sugars (disaccharides) have the formula $C_{12}H_{22}O_{11}$, each molecule being made up of two molecules of a simple sugar minus one molecule of water. The best-known disaccharide is ordinary sugar, which is called sucrose in chemistry. Lump sugar, granulated sugar, and all other kinds of white sugar consist of almost pure sucrose, whether they are beet sugar or cane. Brown sugar is also composed of sucrose, but it contains a trace of water and other impurities. Each molecule of ordinary sugar (sucrose) is composed of one glucose group and one fructose group. Maltose, the sugar of malt, is a disaccharide composed of two glucose groups; and lactose, the sugar of milk, is composed of one glucose and one galactose group.

The polysaccharides are made up of several simple sugars, in much the same way as the proteins are made up of several amino-acids. But there is this great difference. The individual amino-acids show a great variety of structure, while the simple sugars are all very much alike. Moreover, there are about twenty different amino-acids in food proteins, whereas there are only a few different simple sugars in the complex carbohydrates. Often only one simple sugar is present, as in starch, which contains large numbers of glucose groups. Starch is by far the most important polysaccharide in our food. Dextrin, another polysaccharide, resembles starch in composition but is slightly simpler since it contains fewer glucose groups.

Plant foods also supply us with another polysaccharide, cellulose, the material that forms the cell-walls of plants. Cellulose, however, is not a food to be compared with starch, dextrin, or sugar. It cannot be digested or absorbed to any extent in the body, and is therefore said to be 'unavailable'. It is thus of little use for energy-production, but it acts as roughage and helps to keep the digestive system in proper working order. There are a few other unavailable carbohydrates that have a laxative action. Most of them, like cellulose, are insoluble in water; the inulin of artichokes, on the other hand, is soluble in water but partially unavailable. These various substances and cellulose are usually classed together as roughage, a term which also includes some substances which are not true carbohydrates—such as lignin, the woody part of plant fibres, and pectin, the substance that makes jam set.

Most of the carbohydrate in our food comes from plant products. Starch is the principal constituent of flour and all other cereal foods. Sago, tapioca, and arrowroot (which are usually classed with cereals for convenience, though they are not the products of grains) and cornflour contain over 90 per cent. of starch, flour contains 70–80 per cent., biscuits contain 60–80 per cent., and bread 45–60 per cent. Dried legumes contain about 50 per cent. of starch, in the dry state, and about 20 per cent. when soaked and cooked; cooked potatoes also contain about 20 per cent., but cooked green vegetables contain only about 1 per cent. Unripe fruits contain starch, which is converted into sugar during ripening. Dried fruits contain 40–65 per cent. of sugar, bananas about 20 per cent. (this may include some starch), apples about 12 per cent., and soft fruits rather less. Some vegetables contain sugar, notably beetroot, which contains about 10 per cent. of sucrose. White sugar contains nearly 100 per cent. of sucrose, golden syrup contains about 80 per cent. of sugar, honey about 75 per cent., treacle about 70 per cent., and chocolate about 50–55 per cent. Jam and marmalade contain about 50–70 per cent. of sugar, some of which is glucose and fructose, formed by the 'inversion' of sucrose during the process of jam-making. This mixture of glucose and fructose in equal proportions is known as 'invert sugar', and it sometimes occurs naturally: it is, for instance, the characteristic sugar of honey. Purified glucose, which is used for medicinal purposes, is practically pure carbohydrate.

Animal products contain no carbohydrate at all, except that there is sugar (lactose) in milk, and a small amount of animal starch, known as glycogen, in shell-fish and liver. Sausages and some other manufactured meat foods contain carbohydrate; this comes not from the meat, but from the rice, rusk, or other substance added to the meat during the process of manufacture.

The amount of available carbohydrate (in gm. per ounce) in a number of foods is given in the tables on pages 158 to 170 and the percentage of unavailable carbohydrate in fruits and vegetables is given in Table 18, p. 138.

Fats

Like the carbohydrates, the fats contain the elements carbon, hydrogen, and oxygen, but here the proportion and arrangement are quite different. A striking difference is that the fats contain far less oxygen in relation to the amount of carbon. The fat molecule consists of two portions: one portion is derived from glycerol (glycerine) which has the formula $C_3H_5(OH)_3$, and the other consists of three fatty acid groups, which may be all alike or different. Examples of fatty acids are stearic acid, $C_{17}H_{35}COOH$, and oleic acid, $C_{17}H_{33}COOH$. It may be mentioned that in chemistry oils, such as olive oil, are called fats; indeed, the distinction between oils and fats is merely a temperature effect, for when solid fats are warmed up they melt and become 'oils'. The difference in nutritive value of the various fats in our food depends chiefly on the amount of fat-soluble vitamins associated with them. Moreover, a few fats are of special value in nutrition because of containing important fat-like substances; an example is the fat of egg-yolk, which contains lecithin. The chemical nature of the fat itself is not of great importance, except that we must have some fat containing linoleic acid and certain other unsaturated fatty acids, which the body needs but cannot manufacture; the term 'unsaturated' denotes that these substances have so-called 'double bonds' in the molecule. Apart from such special constituents of fat, however, the fat in our food is used in the body either as fuel or for storage purposes.

There is not always the same amount of true fat in what we ordinarily call fats: dripping and lard contain practically 100 per cent. of true fat, whereas butter and margarine contain about 85 per cent., the remaining 15 per cent. being mainly water. The name of 'visible' fat is given to the fat in obviously fatty foods such as butter, margarine, lard, dripping, suet, olive oil, and cotton-seed oil. Besides these, there are a number of foods containing less obvious or 'invisible' fat; for instance, some nuts have over 60 per cent. of invisible fat, most cheese has 30–40 per cent., dried eggs have 43 per cent., soya-bean flour (full fat) 23 per cent., fresh eggs 12 per cent., and milk about 3·6 per cent. Meat contains both visible and invisible fat, totalling about 40 per cent. in roast pork, 35–55 per cent. in cooked bacon, and over 30 per cent. in prime roast beef. Fishes can be divided into two classes according to the amount of fat they contain. On the one hand there are the fatty fish, such as herrings, mackerel, kippers, bloaters, sardines, salmon, and eels, which contain up to 30 per cent. of fat; and on the other hand there are the white fish, such as cod, haddock, and whiting, which contain hardly any fat at all. Cereal products do not contain much fat, except for oatmeal with 8 per cent. Fruit (with a few exceptions such as olives and avocado pears) and vegetables contain practically none. The amount of fat (in gm. per ounce) in a number of foods is given in the tables on pages 158 to 170.

Mineral Elements

We have seen that carbon, hydrogen, and oxygen are supplied by the proteins, carbohydrates, and fats of our food, and that nitrogen is also supplied by proteins. Now we come to the mineral elements in food, the chief of which are sodium, potassium, calcium, magnesium, iron, copper, manganese, chlorine, iodine, fluorine, phosphorus, and sulphur; some of these (copper, manganese, iodine, and fluorine) occur only in minute traces in foods and are therefore called 'trace' elements. About 5 per cent. of the weight of the human body is made up of mineral elements, the greater part being the calcium and phosphorus of bones and teeth. Mineral elements also enter into the composition of all the other body tissues and fluids, and are necessary for the performance of innumerable physiological processes. They have no fuel value as they cannot be burnt. The mineral elements occur either in the form of inorganic salts, such as 'salt' itself, or bound up in proteins or other organic (that is, carbon-containing) compounds; almost all the sulphur in food is bound up in proteins.

Salt itself is practically 100 per cent. sodium chloride. But in most foods the mineral elements occur only in small amounts. The trace elements occur only in minute amounts, just as vitamins do. Apparently our ordinary diets contain adequate amounts of most of the mineral elements that we require, but deficiencies of calcium, iron, and iodine are not uncommon.

Sodium and chlorine. We obtain most of our sodium and chlorine from salt itself and from foods of animal origin. Plant products, on the other hand, provide hardly any sodium; most fresh vegetables contain only about 0·005 per cent., fruits still less, and even dried legumes no more than about 0·06 per cent., while eggs, fish, and lean meat contain about 0·1 per cent. Professor McCance has calculated that if he had to obtain the whole of his daily intake of sodium from potatoes alone, he would have to eat more than twice his own weight of potatoes every day. This is an extreme case, but it shows that people who live mainly on plant products need an extra amount of added salt.

People who perspire very freely also need extra salt, since perspiration contains sodium chloride. This is the physiological explanation of the fact that miners who work in hot pits salt their food heavily and like their bacon to be very salt. The condition known as miner's cramp occurs when large amounts of ordinary water are drunk after excessive perspiration; the remedy is to add a little salt to the drinking-water. People who live in hot countries also perspire a great deal, but they may be protected from excessive salt-loss by acclimatization; when this occurs, the perspiration is watered down so that the concentration of salt is much less than usual. Nevertheless, sodium deficiency may occur in the tropics, especially when salt is unobtainable and when little or no meat is eaten. It is therefore not surprising that salt is often regarded as a luxury in hot countries; in certain parts of Africa the native children eat salt, as children in colder countries eat sweets.

Potassium. Potassium, unlike sodium, is abundant in plant products as well as in animal products: dried legumes, dried fruits, and some nuts contain nearly 1 per cent. or even more. Indeed, the danger with potassium is that our food may supply us with too much, not too little. There is about three times as much potassium as sodium in our bodies, but in plant products there is a far greater preponderance of potassium. Potatoes actually contain over eighty times as much potassium as sodium. Thus it can readily be seen that people who live largely on plant foods may obtain so much potassium in relation to sodium that they may upset the balance between these two elements in the body. To prevent this, these people should increase the amount of sodium in their diet by adding a small amount of extra salt to their food.

Calcium. This element is of great importance in nutrition because calcium phosphate is one of the constituents of bones and teeth. In this country in the past, the children of people in the lower income groups often had diets that were deficient in calcium, with the result that neither bones nor teeth developed properly. The best way to provide against such deficiency is to provide plenty of milk, since milk is rich in calcium. This is one reason why priority allowances of milk are now provided for young children, and why milk is supplied in schools. Any kind of milk acts as a source of calcium, whether fresh, dried, or condensed. Other good sources of calcium are cheese, which contains 0·8 per cent., and fish with edible bones, which contains 0·3–0·8 per cent. Hard drinking-water also supplies it in appreciable amount, and there is a small but useful amount in green vegetables—0·2 per cent. in watercress, and about 0·05 per cent. in cabbage. Spinach is rich in calcium, but it is rendered unavailable by the oxalic acid which is also present. The amount of calcium (in mg. per ounce) in a number of foods is given in the tables on pages 158 to 170.

Phosphorus. Phosphorus, like calcium, is an important component of bones and teeth. Fortunately a number of foods contain a relatively large amount. Herring roe (soft) contains 0·9 per cent. of phosphorus, sardines contain 0·7 per cent., sweetbread and liver 0·6 per cent., kidney, heart, and kippers 0·4 per cent., and most other kinds of meat and fish 0·2–0·3 per cent. Cheese has 0·5 per cent., eggs 0·2 per cent., and milk 0·1 per cent. Some cereal products and nuts contain as much as 0·6 per cent. of phosphorus, but in plant products this element is not all present in an available form; some of it is combined in a substance called phytic acid, which is not at all well utilized in the body. Moreover, the phytic acid of our food precipitates calcium as calcium phytate, a highly insoluble substance which cannot be absorbed and is therefore excreted. Phytic acid thus has an anti-calcifying action. Besides removing calcium from the body, phytic acid may also remove magnesium and iron in a similar way. There is no phytic acid in animal products, and only a small amount in fresh vegetables and fruits. But there is a relatively large amount in dried peas and beans, in some nuts, and in the husks of grains and hence in unrefined cereals (see p. 89); cocoa husks also contain an appreciable amount. The percentage of phytic acid in some foods is given in Table 2, p. 16.

TABLE 2. *The Anti-calcifying Action of Cereals, Nuts, &c., in Terms of Phytic Acid*

	Mg. of phytic acid phosphorus per 100 gm. of food (edible portion)		*Mg. of phytic acid phosphorus per 100 gm. of food (edible portion)*
All-Bran, Kellog's .	619	Cocoa . . .	103
Brazil nuts . .	509	Bread, Hovis . .	98
Almonds . .	363	Biscuits, digestive .	90
Butter beans, raw .	267	Bread, brown (92%)	88
Oatmeal, raw . .	266	Coco-nuts . .	76
Rye flour, 100% extraction. . .	258	Wheat flour, 80% extraction, Manitoba .	65
Barcelona nuts .	248	Rice, polished . .	60
Wheat flour, 100% extraction, Manitoba	245	Rye flour, 75% extraction . . .	57
Peas, dried, raw .	242	Milk chocolate .	39
Shredded wheat .	230	Bread, National (85%)	38
Haricot beans, raw .	226	Flour, white, Manitoba	29
Vita-weat . .	219	Peas, tinned . .	29
Walnuts. . .	214	Rye flour, 60% extraction . . .	24
Peanuts . . .	208	Parsnips, raw . .	21
Soya flour, low fat and grits . .	199	Cornflakes . .	15
Soya flour, full fat .	185	Chestnuts . .	13
Cobnuts . .	169	Figs, dried . .	12
Ryvita . . .	159	Peas, fresh, raw .	11
Peas, split, dried .	153	Bread, white (70%) .	10
Pearl barley . .	136	Artichokes, boiled .	8
Lentils, raw . .	123	Potatoes, new, boiled .	8
Rye flour, 85% extraction . . .	104	Potatoes, old, boiled .	6
Wheat flour, 85% extraction, Manitoba	103	Broad beans, boiled .	5
		Blackberries . .	4
		Carrots, raw . .	3

These figures have been calculated from the values for total phosphorus and those for phytic acid phosphorus expressed as a percentage of the total phosphorus, both of which were taken from *The Chemical Composition of Foods*, by R. A. McCance and E. M. Widdowson (H.M. Stationery Office), 1946.

Magnesium. A small amount of magnesium appears to be necessary for the maintenance of health. Many foods contain this element, and the bran of cereals and some nuts contain as much as 0·4 per cent.; winkles and whelks contain

0·4 and 0·2 per cent. respectively, but most other kinds of meat and fish contain only a tenth of this amount; most vegetables and fruits contain even less, except for dried legumes which have about 0·1 per cent. Magnesium, like calcium, is rendered unavailable by phytic acid.

Iron. Iron is of great importance in the body because it is a constituent of haemoglobin, the red colouring matter of the blood. If our diet lacks iron we become pale and anaemic. In this country, deficiencies of iron are apt to occur in the diets of adolescent girls, and of women, especially during pregnancy. In our ordinary diets there is enough iron to supply the needs of men, but not enough for women and girls, who eat less total food than men do and hence obtain less iron, and who have to compensate for periodical losses of blood. None of our foods are very rich in iron. Milk contains practically no iron at all. Foods that are relatively rich include liver and kidney, which contain 0·02 and 0·015 per cent. respectively, winkles with 0·017 per cent., whelks 0·006 per cent., whitebait and sprats 0·005 per cent., sausages 0·003 per cent., black treacle 0·009 per cent., dried legumes 0·005–0·008 per cent., mustard and cress 0·005 per cent., oatmeal and rolled oats 0·004 per cent., eggs 0·0025 per cent., dried fruits 0·002–0·007 per cent., brown bread and National bread 0·002 per cent. The amount of iron (in mg. per ounce) of a number of foods is given in the tables on pages 158 to 170. As might be expected, a considerable amount of iron is added to our food when iron utensils are used, such as mincing-machines, iron pans, and non-stainless steel knives. Chipped enamel-ware also adds iron, but it is undesirable on other grounds.

The question of the availability of iron in food is a very difficult one. At one time it was thought that iron could not be used in the body if it was bound up in proteins, as is the iron of blood; but further work has shown that this iron is by no means completely unavailable. A further complication is that iron, like calcium, is precipitated by phytic acid and in this way rendered unavailable.

Copper. Apparently a trace of copper is essential for health, although of course copper is poisonous in larger quantities. Foods that contain iron usually contain traces of copper too, and most ordinary diets supply us with as much copper as we require.

Manganese. There are small traces of manganese in some foods, but it is not yet certain whether we need this element or not.

Iodine. Iodine is one of the constituents of thyroxine, the active principle of the thyroid gland, and a deficiency of iodine in the diet leads to an unsightly enlargement of the thyroid gland known as a goitre. We obtain our iodine chiefly from sea-fish and drinking-water. In some districts there is a deficiency of iodine in the drinking-water, and here goitre is often found, especially in remote places where sea-fish is hardly ever obtainable. The weekly visit of a fishmonger has indeed been enough to reduce the incidence of goitre in some villages—an argument in favour of improving the distribution of sea-fish. But even fish-eating people may not get as much iodine as they require. Fortunately, however, an adequate supply of iodine can be obtained quite easily, by using iodized salt instead of ordinary salt. Iodized salt consists of ordinary salt to which a minute amount of sodium or potassium iodide has been added. It can do no harm to anyone, and is of great benefit to people who live in goitrous areas. It would be an excellent plan if all the salt used as food in this country were iodized. The adoption of such a national policy has recently been urged by the Goitre Sub-committee of the Medical Research Council, the proportion of iodine recommended being 1 part of potassium iodide to 100,000 parts of common salt.

Fluorine. An extremely small amount of fluorine occurs in bones and teeth, and there is some evidence that a trace of fluorine in the diet is necessary for the proper development of teeth, although it is well known that anything above a minute trace is definitely harmful. Our chief sources of fluorine appear to be drinking-water and sea-fish. In some districts there is too much fluorine in the water, and a disease known as fluorosis occurs. The most obvious symptom of fluorosis is mottled teeth, that is, teeth with irregular whitish patches or bands on the enamel. Mottled teeth do not look very nice, but apparently they decay less readily than ordinary teeth. Presumably teeth would be at their best if they contained just enough fluorine to give good structure and prevent decay, but not enough to cause mottling. Such a condition of teeth has actually been found among the inhabitants of Tristan da Cunha, a lonely island in the South Atlantic Ocean. Here the water does not contain over-much fluorine, but the people eat a great deal of sea-fish. The teeth show only the slightest sign of mottling and are remarkably free from decay. In this country, cases of mild fluorosis with mottled teeth have been observed, especially at Maldon in Essex, and also in Upper Weardale, the Spilsby area of Lincolnshire, St. Austell, and the counties of Cambridge, Bedford, Oxford, Somerset, and Glamorgan.

Vitamins

The vitamins are not all related to each other chemically —far otherwise—but it is convenient to group them together. All of them are organic compounds that are concerned with the control of bodily activities; at the same time, most of them protect the body against specific deficiency diseases. The vitamins occur in foods only in minute amounts, and in this respect they resemble the trace elements. But the chemical composition of the two groups is very different, for the vitamins are organic (carbon-containing) compounds whereas the trace elements are inorganic (mineral). There is also this fairly marked difference between vitamins and mineral elements: deficiency of a mineral element usually leads to similar symptoms in different species of animals (lack of iron leads to anaemia, lack of calcium leads to poor bone development, and so on), but deficiency of a vitamin often exhibits itself in different ways in different species of animals.

The chemical nature of the various vitamins, together with their history and significance, will be discussed in a later chapter (see p. 43). Tables showing foods rich in vitamins are given on pages 148 to 156.

Flavour and Nutritive Value

Our food contains a number of substances that do not fit into any of the categories already mentioned. For instance there are the extractives of meat, the so-called 'essential oils' of fruits, and the characteristic flavouring materials of mustard, pepper, and spices. These substances are by no means without value; they add to the attractiveness of food, and that in itself is of considerable importance. It is often supposed that people who work on nutrition care nothing at all for flavour, though this is not borne out by an examination of their private lives. They are just as likely to be gourmets as any other people. At the same time, they realize that flavouring materials must take a secondary place in nutrition, unless they supply us with some essential nutrient. For this reason we shall not deal with the chemistry of flavouring materials, except for the extractives which will now be considered briefly.

Extractives. In meat and fish, and in some plant products, there are small amounts (usually less than 0·3 per cent.) of substances that are loosely classed together as extractives. They are non-protein organic compounds which contain nitrogen, but which are not necessarily related to one another chemically. The name 'extractives' simply means that these substances are extracted from food when it is boiled in water; most proteins, on the other hand, are coagulated (solidified) by heat and therefore cannot be extracted in this way. It must be admitted that the extractives have been somewhat neglected by research workers. Some of them, it is true, are well known, but it is not yet clear which particular compounds are responsible for the properties vaguely ascribed to the group as a whole. Curiously enough, some of the components of meat extracts, previously included under the heading of extractives, have recently turned out to be vitamins (see p. 104).

The extractives of meat are responsible for its flavour. They occur in meat extracts, meat gravy, meat soup, and in lean meat itself unless removed during cooking. They cannot be burnt in the body and therefore have no value as fuel, nor do they appear to be used for body-building. But they play an interesting part in digestion, as we shall see in the next chapter.

Water

Before we leave the chemistry of food, a word must be said about water. It is essential for all forms of life. With no food other than water, human life can be maintained for a fairly long time, and there are apparently well-authenticated records of people who have lived on water alone for over six weeks. Water forms about two-thirds of the weight of the body, and is present in all the tissues and fluids. We need it for all the chemical reactions that take place in the body, and for dissolving waste products. It has no fuel value as it cannot be burnt. In a temperate climate, an average man engaged in light work loses about 2¾ pints of water a day by excretion, nearly ¾ pint as water vapour from the lungs, and about a pint as 'insensible' perspiration; during periods of heavy muscular exercise, there is a further loss of water owing to perspiration. In a hot climate about 5 pints of water a day may be lost regularly as perspiration, and in an extremely hot climate this loss may amount to as much as 17 or 18 pints a day.

We obtain our water not only from water itself and from beverages, but also from solid foods, most of which contain a good deal of water. There is about 70–94 per cent. of water in the edible part of fresh fruit, about 68–98 per cent. in boiled vegetables, and nearly 80 per cent. in steamed white fish. Beverages are often composed almost entirely of water. Milk contains 87 per cent., wine 80–93 per cent., and even spirits and liqueurs are often more than half water. An average man in a temperate climate usually obtains about 2½ pints of water a day from water itself and other beverages, and about a pint and a third from solid foods.

Besides the water from food and drink, the body also obtains a regular supply of 'internal' water from the oxidation (burning) of the hydrogen in energy-producing foods. In this process of oxidation the carbon of fats, carbohydrates, and proteins is oxidized to carbon dioxide (CO_2) and the hydrogen is oxidized to water (H_2O). Quite a considerable amount of water is produced in the body in this way. For instance, the average man engaged in light work, whom we have already had occasion to mention, obtains about two-thirds of a pint of 'internal' water a day. Fats produce more 'internal' water than carbohydrates or proteins because they contain a higher proportion of hydrogen. Fats actually produce slightly more than their own weight of water when they are burnt in the body. This is particularly convenient for camels. They keep large stores of fat in their humps, and burn it as fuel when they have neither food nor water; in this way they provide themselves with extra water. This is one reason why camels are so useful for journeys across the desert. They can travel for 10 days without water. They obtain the water they require partly from reserves of water in the stomach, and partly from the oxidation of the fat in the hump. At the beginning of the journey the hump is large and firm, but at the end it sags because the fat has been used up. The camel can almost be said to travel upon its hump.

CHAPTER II

DIGESTION

It 's a very odd thing—
As odd as can be—
That whatever Miss T. eats
Turns into Miss T.

DE LA MARE.

NEARLY four centuries ago the alchemist Paracelsus taught that there is in each one of us a good spirit, an archaeus, who uses the good qualities of our food for our nourishment and expels those things which would harm us. The modern view of digestion is less picturesque and less simple. The archaeus of Paracelsus has given place to a complicated series of chemical reactions.

Most of the food we eat cannot be used in the body until it has been broken down into small particles and then changed into simpler substances which can be absorbed by the body. There are, however, a few constituents of food that can be absorbed without having to undergo any chemical change. Water, mineral salts, and vitamins come into this category. The only energy-producing substances that can be absorbed without change are alcohol and the simple sugars, such as glucose. This power of being quickly absorbed without causing any tax on the digestive system gives these substances a special value in emergencies when an immediate supply of fuel is required.

All other foods have to go through some process of digestion before they can be absorbed and used by the body. The various stages of digestion take place in the alimentary canal, which is about 30 feet long, and which has some portions, such as the stomach, that can be shut off by valves from the neighbouring sections if necessary (see Fig. 1, p. 24). The actual process of digestion is brought about by means of substances known as enzymes, which are present in the digestive juices.

Carbohydrates. The first enzyme to be encountered by the food occurs in the saliva of the mouth. Even before food enters our mouths, the saliva begins to be secreted if the sight or smell of the food affects us favourably, but not otherwise. The mere thought of attractive food or the sound of the dinner-gong is enough to make the mouth water, that is, to cause a flow of saliva. This secretion is psychological in origin and is under the control of the nervous

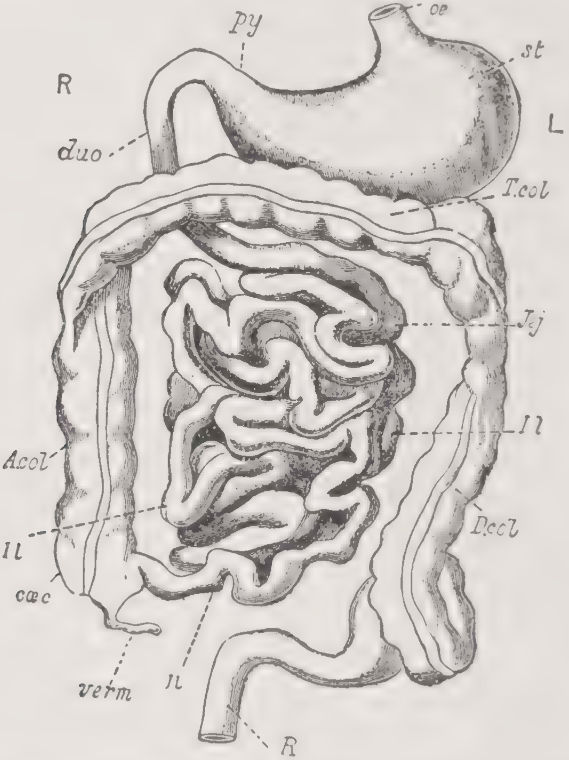


FIG. 1. Diagram of the Alimentary Canal (Abdominal Portions)

oe, lower end of the oesophagus or gullet; *st*, stomach; *py*, pylorus; *duo*, duodenum or first part of the small intestine; *Jej* and *Il*, small intestine; *caec* (caecum) and *A.col*, *T.col*, and *D.col* (ascending, transverse, and descending colon), and *R* (rectum), large intestine; *verm*, vermiform appendix. [From *Lessons in Elementary Physiology*, by T. H. Huxley (Macmillan & Co., Ltd.), 1915.]

system. When we start eating, the taste of the food causes a further secretion of saliva. The chief functions of the saliva are to moisten the food and to digest the starch, but the action on starch takes place mainly when the food reaches the stomach. While the food is in the mouth, it is disintegrated by the teeth and mixed with the saliva.

When the food leaves the mouth it passes through the gullet into the stomach, and it is here that the enzyme of the saliva does most of its work, converting starch by stages into maltose. Cooked starch is digested far more readily than uncooked. In the stomach the food meets the gastric juice, which we shall deal with later when we come to proteins. Eventually the hydrochloric acid of the gastric juice stops the digestion of starch by the saliva. But it takes a certain amount of time for the food mass to become thoroughly mixed with the acid, so that for about half an hour the digestion of starch proceeds in the stomach unhindered.

Any starch that escapes the action of the saliva is converted into maltose by the pancreatic juice in the duodenum, the first part of the small intestine. Moreover, in the small intestine the disaccharide sugars, such as maltose and ordinary sugar, are split up into their component simple sugars (glucose, fructose, and so on) by the enzymes of the intestinal juice (see Table 3, p. 26). The simple sugars are absorbed by the cells that line the walls of the lower part of the small intestine, and pass into the blood-stream. They are finally used mainly as fuel.

Thus all the sugars and starches of our food are absorbed in the form of simple sugars. They all provide the body with the same type of fuel and are more or less equally useful as fuel foods. In cases of illness, however, glucose may have a special value because it is very easily absorbed and can be given in larger quantities than ordinary sugar since it is not so sweet. Ordinary sugar has the disadvantage that it may cause irritation of the stomach if it is taken in large amounts with little or no water to dilute it.

The sugars and cooked starch are the most easily digested of all the constituents of food. If they are eaten in excess of bodily requirements, a small amount is stored in the body in the form of glycogen (animal starch) and the rest is converted into fat and stored in this form. Cellulose and other types of roughage, on the other hand, cannot be digested by the body enzymes, though they are to some extent fermented by the bacteria that are always present in the large intestine. The gas produced as a by-product of this action causes considerable discomfort. Intestinal bacteria may also attack, in a similar way, any particles of uncooked starch that escape digestion.

TABLE 3. *Summary of the Action of the Chief Digestive Enzymes*

Enzymes		*Secreted by*	*Action*
Act on Carbohydrates	Ptyalin (salivary amylase)	Salivary glands	Converts starch to maltose
	Amylopsin (pancreatic amylase)	Pancreas	Converts starch to maltose
	Invertase (sucrase)	Intestinal mucosa	Converts sucrose to glucose and fructose
	Maltase	Intestinal mucosa	Converts maltose to glucose
	Lactase	Intestinal mucosa	Converts lactose to glucose and galactose
Act on Fats	Lipases	Gastric mucosa and pancreas	Split fats to fatty acids and glycerol
Act on Proteins	Pepsin	Gastric mucosa	Splits proteins to proteoses and peptones
	Trypsin	Pancreas	Splits proteins to proteoses, peptones, polypeptides, and amino-acids
	Erepsin	Intestinal mucosa	Splits peptones to amino-acids and ammonia

[From *Chemistry of Food and Nutrition*, by H. C. Sherman (The Macmillan Company), 1941.]

Proteins. The proteins are not digested by the saliva, but undergo the first stage of their digestion in the stomach under the action of the gastric juice. Even before the food has been tasted, gastric juice begins to flow into the stomach, if the anticipation of food arouses pleasant sensations. The amount of gastric juice secreted depends a good deal on the strength of this stimulus. The secretion of gastric juice is also stimulated by condiments (pepper, mustard, curry, &c.), spices, and flavouring materials. Moreover, anything that increases the general sense of well-being tends to increase the 'appetite' flow of gastric juice. Good food, good wine, and good company all serve to assist digestion. The beneficial effects of alcohol and condiments, however, depend on moderation.

The secretion of the gastric juice, which is promoted in such agreeable ways, is diminished by adverse circumstances. If the food is cooked or served in such a way that it takes away the appetite, the gastric juice will not be properly secreted. A sudden piece of bad news or a violent outburst of anger may have the same result. To secure good digestion, meals should be eaten without undue excitement. The old Army tradition that religion, politics, and women must not be mentioned in the officers' mess thus had a physiological justification. Strenuous exercise just before a meal may also interfere with protein digestion but in a different way; it decreases the acidity of the gastric juice and diverts blood away from the stomach. This accounts for the fact that children are sometimes sick if they are made to eat a heavy meal when they are over-tired.

Besides the psychological factor in gastric secretion, there is also a chemical factor, which is capable of acting even when the psychological factor fails. Certain chemical compounds cause a flow of gastric juice when they reach the stomach. The chief of these substances are the extractives of meat, which are present in meat juice and meat extracts. Soup usually contains extractives, and is therefore an excellent course with which to start a meal, especially for people who are worried and for those who have feeble appetites.

When the gastric juice has been secreted, whether by means of chemical or physiological stimuli or both, it proceeds to carry out the first stage of the digestion of the proteins. This stage is assisted by the acid reaction of the gastric juice. It results in the formation of simpler substances, such as peptones, from the complex proteins of the food. After leaving the stomach, the peptones are further digested by pancreatic enzymes, and some of them are converted into their component parts, the amino-acids. Finally, an enzyme in the intestinal juice digests the few remaining proteins in a similar manner, so that eventually all the proteins are completely broken down into amino-acids. These are absorbed in the small intestine and pass into the bloodstream. They are used for building up the body proteins, or indirectly as fuel.

An interesting point about the body proteins is that they are constantly being broken down and built up again. This is true of fats too. The materials of the body are in a state of continuous flow although the composition of the body tissues remains unchanged, just as a fountain keeps the same shape although new water flows through it. Some of the amino-acids from our food proteins make their way into our flesh, and the amino-acids displaced in this way are used as fuel. When an amino-acid is to be used as fuel, the nitrogenous portion is split off, and the remaining portion is either burnt at once or converted into glycogen and stored in this form. The nitrogenous portion, which cannot be burnt in the body, undergoes chemical change and is finally excreted as urea.

Fats. The digestion of fats takes place in the small intestine by the action of the pancreatic juice. (There is also a fat-splitting enzyme in the gastric juice.) The bile juice assists in this action by emulsifying the fats and thus enabling them to come into more intimate contact with the pancreatic enzyme. The process of digestion consists in splitting the fats into their two component parts, fatty acids and glycerol. These substances are absorbed in the small intestine.

It appears from recent work, however, that the fat in our food is not all digested in this way. Some of it is emulsified very finely indeed and absorbed in the small intestine directly, without being split into fatty acids and glycerol. The unsplit fat is apparently stored in the fat deposits of the body, whereas the fatty acids go to the liver and serve as a more immediate source of fuel. The proportion of fat that is absorbed directly appears to vary from one person to another, and it is tempting to suppose that this might explain why some people are constitutionally fat and others thin. Do people remain slim merely because they are not particularly good at finely emulsifying the fat in their food? On the other hand, if people are very good at this, are they predestined to be fat?

The burning (oxidation) of fat is a slow and complicated process, which can only be carried to completion (that is, to CO_2 and H_2O) if carbohydrates are also present. If there is not enough carbohydrate present, the oxidation stops short when aceto-acetic acid has been formed. Instead of being further oxidized, this accumulates in the body, and part of it is converted into other substances (acetone and hydroxy-butyric acid). Acetone and aceto-acetic acid itself contain what is known as the ketone group. These ketones are poisonous and give rise to ketosis (biliousness). In order to prevent the onset of ketosis, it is necessary to balance the fat in the food with carbohydrate. People who suffer from bilious attacks should therefore eat plenty of starchy and sugary foods and not too much fat (unless they are diabetics).

Food mixtures. One of the favourite illusions of food faddists is that proteins and carbohydrates are mutually incompatible and should not be eaten together. This is of course absurd. The various digestive enzymes are well able to work side by side, and indeed they form a kind of chain; when one enzyme has finished its work, another is secreted, and so on. There is no objection at all to the common practice of eating carbohydrates and proteins together. If these substances were truly incompatible we should hardly be able to eat anything at all. We should have to cut out of our diet bread, peas, beans, nuts, and even milk, since all these foods contain both protein and carbohydrate.

The absorbability of food. Although nearly all the food in a mixed diet is digested and absorbed, there is always a small proportion that is excreted as waste material. The amount of this unabsorbed residue depends chiefly on the type of food eaten. Table 4 shows that 97 per cent. of the carbohydrate of a mixed meal is absorbed and 95 per cent. of the fat. Protein from animal sources is also very well absorbed, but that from plant products leaves an appreciable quantity of unabsorbed residue, which is liable to be attacked by putrefactive bacteria in the alimentary canal.

TABLE 4. *The Absorbability of Food*

	Percentage absorbed from mixed diet		
	Protein	*Fat*	*Carbohydrate*
Meat and fish	97	95	98
Eggs, milk, butter, and cheese	97	95	98
Total animal food of mixed diet	97	95	98
Cereals and bread	85	90	98
Dried peas and beans	78	90	97
Sugars and starches	. .	. .	98
Vegetables	83	90	95
Fruit	85	90	90
Total plant food of mixed diet	84	90	97
Total food of mixed diet	92	95	97

[Based on a table in *Principles of Nutrition and Nutritive Value of Food*, by W. O. Atwater, U.S. Dept. of Agriculture, Farmers' Bulletin No. 142, 1902, p. 27.]

Muscular movements of the wall of the alimentary canal. In order that the proteins, carbohydrates, and fats can reach the appropriate digestive enzymes, the food has to be continually churned up when it is in any particular section of the alimentary canal, and the food mass has to be passed along at certain times from one section to the next. Both these actions are brought about by means of the muscular movements of the wall of the alimentary canal.

The muscular movements of the stomach are increased both in frequency and in strength by hot foods, and a similar effect is produced by spices, condiments, alcohol, and effervescent drinks. The movements become more vigorous as digestion proceeds, possibly because the increasing acidity acts as a stimulant. But anxiety stops the movements of the stomach and leads to nervous indigestion. The movements of the small intestine (peristaltic waves) are also affected by the nervous system. They tend to be diminished by pain and worry, but exaggerated by emotional excitement.

The movements of the large intestine are of great importance, and constipation results if they fail. By the time the food residue reaches the large intestine, the proteins, sugars, starches, and fats have all been digested and absorbed. Some water still has to be absorbed, and cellulose and other roughage remain undigested. The roughage helps to prevent constipation in several ways. In the first place it stimulates the muscular movements of the intestinal wall by friction. Moreover, it adds to the bulk of the faeces, and also absorbs water and thus prevents the formation of hard dry faeces. As we have seen, cellulose and other unavailable carbohydrates are to some extent broken down by bacteria in the intestine, and there is some evidence that the products of this breakdown are absorbed by the intestinal walls and stimulate peristalsis in this way.

The Digestibility of Food

After this brief survey of the digestive processes we can approach the question of the digestibility of food. Strictly speaking, digestibility should mean the capacity to be completely digested, but in order to avoid confusion it will be used here, as it is in general conversation, to mean merely the rate at which food is digested. When we say that a food is indigestible we therefore mean that it will take a long time to be digested, not that it cannot be digested at all. Similarly, highly digestible foods are those that are digested in a relatively short time.

Fluids and semi-fluids begin to leave the stomach almost immediately after being swallowed. But solids do not leave the stomach so quickly, and it takes from three to four and a half hours for the stomach to empty itself after an ordinary mixed meal. Carbohydrates leave the stomach the most rapidly, and proteins occupy an intermediate place. Fats leave the most slowly, and it is this prolonged period in the stomach that gives us the pleasant feeling of inward satisfaction which follows a meal containing a good deal of fat and is so noticeably absent after a meal consisting largely of carbohydrate. Contrast, for example, the well-known empty feeling that develops an hour or two after a breakfast of porridge (mainly carbohydrate) with the comfortable feeling of repletion that remains after a meal of bacon and eggs (fat and protein). It is, however, unwise to have too much fat with protein because fat delays the digestion of proteins. This is one reason why very fat meats such as pork and goose are indigestible.

The physical state of the food also has a considerable influence on the digestibility. Proteins, carbohydrates, and fats are all digested by different enzymes, and the body has to separate out the various nutrients, so that each enzyme can come into contact with the particular substance it is able to digest. This is difficult to do if the food is in a glutinous or leathery mass, and in these cases digestion is accordingly delayed. This accounts for the indigestibility of very new bread, hard-boiled eggs, and such cheese dishes as Welsh 'rabbit'. Ordinary hard cheese is digested slowly owing to its high fat content, and when it is cooked it takes even longer to digest because the fat melts and saturates the other food constituents. The body has to undo all that the cook has done. It is no wonder that suppers of toasted cheese are often followed by nightmare. All foods that are fried, or impregnated with fat in other ways, take a long time to digest, and the indigestibility of rich pastry, puddings, &c., is due to the high fat-content and the intimate way in which the fat is mixed up with the other ingredients.

Indigestion

Mark Twain once said that the secret of success in life is to eat whatever you like and let the food fight it out inside. Although this was said in jest, it contains an element of truth. Some people undoubtedly worry far too much about food, with the result that they give themselves indigestion; for, as we have seen, anxiety leads to digestive troubles.

Another cause of indigestion is sedentary work. People who have to work indoors should try not to sit all the time in a cramped position, and should spend as much as possible of their leisure time in the open air, either walking, gardening, or taking exercise in some other way. Motoring is responsible for a good deal of indigestion, and some people are able to cure themselves of digestive troubles by walking to their work instead of going in a car or bus. Over-eating should be avoided, since this in itself is capable of causing indigestion even in healthy people. Other suggestions for avoiding indigestion are as follows: have regular meals, eat slowly, and rest for a short time after meals; be sparing with condiments and highly flavoured dishes; drink plenty of water but not too much tea, coffee, or alcohol, and beware of fried food, rich pastry, and other foods that contain a great deal of fat.

Acidity

When the combustible part of our food has been burnt as fuel, the residue left in the body may be either acid or alkaline. The reaction depends chiefly on the nature of the mineral elements. Acid residues are yielded by the non-metallic elements (chlorine, phosphorus, and sulphur) and alkaline residues by the metallic elements (sodium, potassium, calcium, magnesium, iron, and copper). Foods can be divided into two groups according to the reaction of the mineral residue. Thus, bread and other cereal foods, meat, poultry, game, fish, and eggs yield acid mineral residues, while fruits, vegetables, nuts, and milk yield alkaline mineral residues. In some fruits, however, the alkalinity of the mineral residue is more than neutralized by the presence of unoxidized organic acids. Citric acid and most other organic acids are used as fuel in the body and completely oxidized, so that although the original fruit is acid it leaves an alkaline not an acid residue. But a few organic acids are not completely oxidized and give rise to acid residues; for instance, cranberries, plums, and prunes contain relatively large amounts of quinic acid, which is converted into hippuric acid instead of being oxidized completely. An excess of foods yielding acid residues is sometimes thought to be harmful, but more evidence is needed before a final decision can be made.

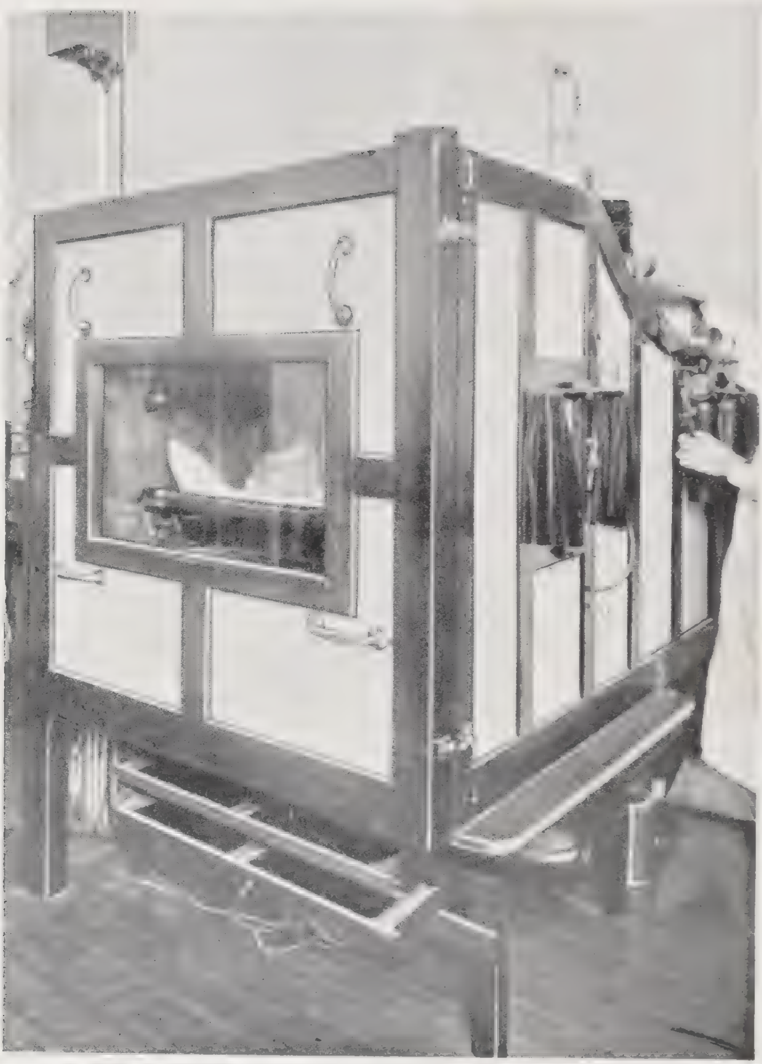


Fig. 2. Photograph of a calorimeter, taken during an experiment on basal metabolism.

This calorimeter was formerly at the Russell Sage Institute of Pathology, but it is now installed in New York Hospital. [From *The Science of Nutrition*, by Graham Lusk (W. B. Saunders Co.), 1928. I am much indebted to Dr. Du Bois for kindly lending me the picture from which this reproduction was made.]

CHAPTER III

FOOD AS FUEL

Men ought to beware that they use not exercise and a spare diet both; but if much exercise, then a plentiful diet, and if a sparing diet, then little exercise.

BACON.

WE have seen that most of the food we eat is used as fuel to supply our bodies with energy and warmth. Even rapidly growing children need far more food for fuel than for growth. The more muscular work we do, the more fuel we require. But we still continue to burn fuel when we are resting, because energy still has to be provided for the beating of the heart, the movements of the chest during breathing, and other bodily activities.

The body fuel consists of fats, carbohydrates, and (indirectly) proteins. When these substances are burnt (oxidized) in the body, energy is liberated. This energy is used for muscular work, and is finally transformed into heat. Bodily heat is thus the end-product of muscular work. The more you use your muscles, the more fuel you use up and the more heat you produce. This is why you get hot when you take exercise.

The amount of heat given off by the body can be measured as follows. Let us suppose that we want to find out the basal metabolism of a young man, that is, the amount of heat produced when he is lying down and resting. We must ask the young man to remain without food overnight and then lie down for an hour or two in a calorimeter, a closed chamber with a special device for recording the amount of heat produced inside (see Fig. 2, facing p. 36). Heat is measured in calories (from the Latin *calor* = heat) just as length is measured in inches, weight in ounces, and so on. The calorie used as a unit of measurement in experiments of this kind is a kilocalorie—the amount of heat required to raise the temperature of one kilogram of water one degree centigrade; strictly speaking, it should be spelt 'Calorie' with a capital 'C', but a small 'c' is nearly always used nowadays in nutrition studies.

A great deal of careful scientific work has been carried out with the human calorimeter, and it has been found that the amount of heat given off by the body at rest (the basal metabolism) is about the same for full-grown people of the same sex and the same build. Tall thin people, however, give off more heat than short fat people of the same weight. This is because heat-loss depends chiefly on surface area. Tall thin people have a larger surface than people of the same weight who are short and fat; the more thin and angular you are, the larger will be your surface area, and the more heat you will give off per stone of body-weight. But if we consider the amount of heat lost by a single inch of surface area, we find that it is about the same for all men, whether thin or fat, but on the average it is slightly less for women than for men.

Energy Requirements

Experiments carried out with the calorimeter have shown that the heat production of a healthy young man of average weight (11 stone) is about 70 calories an hour when he is lying down at rest; in other words, every hour that he rests his body uses up an amount of fuel equivalent to 70 calories. If he sits on a chair instead of lying down, his heat production goes up to about 100 calories an hour. This striking result explains why it is an advantage for patients in periods of great bodily weakness to lie down. There may be reasons against their doing so, for instance, if there is lung trouble; and there may be other advantages in lying down, for instance, the even warmth of bedclothes. But the main fact is clear enough: to lie down is to save energy. As might be expected, the calorie output is increased very much during exercise. Our healthy young man produces about 200 calories an hour when he is engaged in moderate exercise;

and if his muscular work is increased, his energy production will be correspondingly higher.

From these figures we can get some idea of the number of calories needed in 24 hours by a moderately active man of average weight. Let us suppose that he sleeps for 8 hours (8 × 70 = 560 calories), sits for 8 hours (8 × 100 = 800 calories), and is engaged in moderate exercise for 8 hours (8 × 200 = 1,600 calories), then his total energy requirement for the day will be 2,960 calories. We shall consider the question of calorie requirements in more detail in a later chapter (see p. 68), but at this point we can take 3,000 calories a day as the average requirement of a moderately active man.

Women, on the average, need fewer calories than men, for several reasons. In the first place, the average weight of women (9 stone) is less than that of men; secondly, women are usually less muscular and active than men are; and thirdly, as we have already seen, the loss of heat per unit of surface area is slightly less with women than with men. The average requirements of children depend on age and sex, but after the first year children always need more calories per unit of surface area than adults do. On the other hand, in old age the bodily activities diminish and fewer calories are needed.

Effect of muscular work. Walking slowly (about 2½ miles per hour) uses up about 200 calories an hour, walking quickly (3¾ miles an hour) uses up about 300, swimming 500, and running 570. The limit of human endurance for a sustained effort seems to be reached when the heat production is about 600 calories an hour, but it may be nearly twice as much as this in short spurts of violent exercise. For instance, when the famous Yale crew of 1924, which distinguished itself at the Olympic Games in Paris, rowed a 4-mile race in 22 minutes, it was found that the average heat production was at the rate of 1,140 calories an hour.

Different occupations use up very different amounts of energy. A typist with a speed of 50 words a minute uses up about 140 calories an hour, a stone-mason uses up 400, and a man sawing wood 480. Even piano-playing uses up a certain amount of energy. Playing Beethoven's *Sonata appassionata* increased a man's calorie output by 140 per cent., one of Chopin's *Études* increased it by 174 per cent., and Liszt's *Tarantelle* by 200 per cent. Oddly enough, brain work uses up no extra calories; both undergraduates and professors have to be classed as sedentary workers unless they take a good deal of muscular exercise in their spare time.

If we take 3,000 calories a day as the average requirement for moderately active men, we must take a higher value for those who lead more active lives. Thus joiners require on the average about 3,600 calories, university boat crews in training 4,000, furniture removers and gardeners 4,500, and miners 5,000.

Effect of fasting. The calories required for basal metabolism and for muscular exercise are normally provided by food. But if no food is eaten, the body reserves of glycogen and fat have to be used for energy production; and if starvation is continued, the body protein is also used as fuel. From this we see that fasting should not be kept up for long periods or the body tissues themselves will be drawn upon, and health will be impaired.

The Calorie Value of Food

Having determined the amount of energy that must be supplied as food in order to protect the body from the ravages of starvation, and to compensate for the amount of muscular exercise taken, we must now obtain a measure of the calorie value of various types of food. This is sometimes called the fuel value of food, or the energy value; it may be mentioned that the word 'energy' is used here in a special sense, meaning the energy expended when we use our muscles, whereas in general conversation energy has the wider meaning of vitality and vigour.

When carbohydrates or fats are completely burnt (oxidized) in the body to the final stage of carbon dioxide and water, the amount of heat given off is the same as when these substances are completely oxidized in the laboratory. The apparatus for such laboratory oxidations is a small calorimeter, known as the bomb calorimeter because it is a thick-walled vessel that looks rather like a bomb. The calorie value of fats and carbohydrates can be measured directly by using the bomb calorimeter. But with proteins an allowance has to be made, because in the body the oxidation stops short when urea is formed, whereas in the bomb calorimeter it is carried to completion.

As the result of pioneer experiments carried out eighty years ago in Munich, Rubner came to the conclusion that every gramme of protein or carbohydrate burnt in the human body yields 4·1 calories, and every gramme of fat yields 9·3 calories. The distinguished American workers, Atwater and Bryant, however, later suggested new factors in order to make allowance for the unabsorbed food in an ordinary mixed diet:

	Calories per gramme	
	Rubner factor	*Atwater and Bryant factor*
Protein	4·1	4
Carbohydrate . . .	4·1	4
Fat	9·3	9

Both sets of factors show that fat yields more than twice as many calories as an equal weight of either protein or carbohydrate.

From the factors for protein, carbohydrate, and fat we can calculate the calorie value of any food, if we know how much of these nutrients it contains. For instance, let us calculate the calorie value of an ounce of fried mackerel. The food table on page 161 shows that 1 ounce of fried mackerel contains 5·7 grammes of protein and 3·2 grammes of fat. If we use the Rubner factors for protein and fat, we find that an ounce of fried mackerel yields

$$(5{\cdot}7 \times 4{\cdot}1) + (3{\cdot}2 \times 9{\cdot}3) \text{ calories,}$$

which works out at 53·13 calories.

Even this simple calculation, however, is unnecessary because the calorie values of foods are given with the analyses in food tables. Originally, the tables of Atwater and Bryant (*The Chemical Composition of American Food Materials*, U.S. Dept. of Agriculture Expt. Sta. Bull. 28, revised in 1906) were used both in the U.S.A. and in this country. English foods were studied systematically first by Professor R. H. A. Plimmer, whose *Analyses and Energy Values of Foods* was published in 1921, and more recently for the Medical Research Council by Professor R. A. McCance and Miss E. M. Widdowson, whose book on *The Chemical Composition of Foods* is now regarded as the standard English work. The latest American tables, sponsored by the National Research Council, are called *Tables of Food Composition in Terms of Eleven Nutrients*. The calorie values given in this chapter are those of Professor McCance and Miss Widdowson. They used the Rubner factors for their calculations, because they consider that it is best to give the calorie value of the food as analysed, without making allowances for unabsorbed foods, since these vary with different diets. In the U.S.A., however, it is customary to use the Atwater and Bryant factors.

We have seen that fat yields far more calories than the same weight of either protein or carbohydrate. For this reason, fatty foods have the highest calorie values. Thus, dripping and lard, both of which contain practically 100 per cent. of fat, yield the extremely high value of 262 calories per ounce, and butter and margarine with 85 per cent. of fat yield 226. Sugar, with its 100 per cent. of carbohydrate, yields only about half as much energy as an equal weight of butter or margarine, and bread yields about a third. The fat of meat, like other fats, has a high calorie value, far higher than that of the lean; for instance, the fat of roast beef yields over 250 calories per ounce while the lean yields about 60–70. There are two reasons for this fairly low value for the lean; first, protein, as we have seen, provides far less calories than fat, and secondly, lean meat (cooked) contains

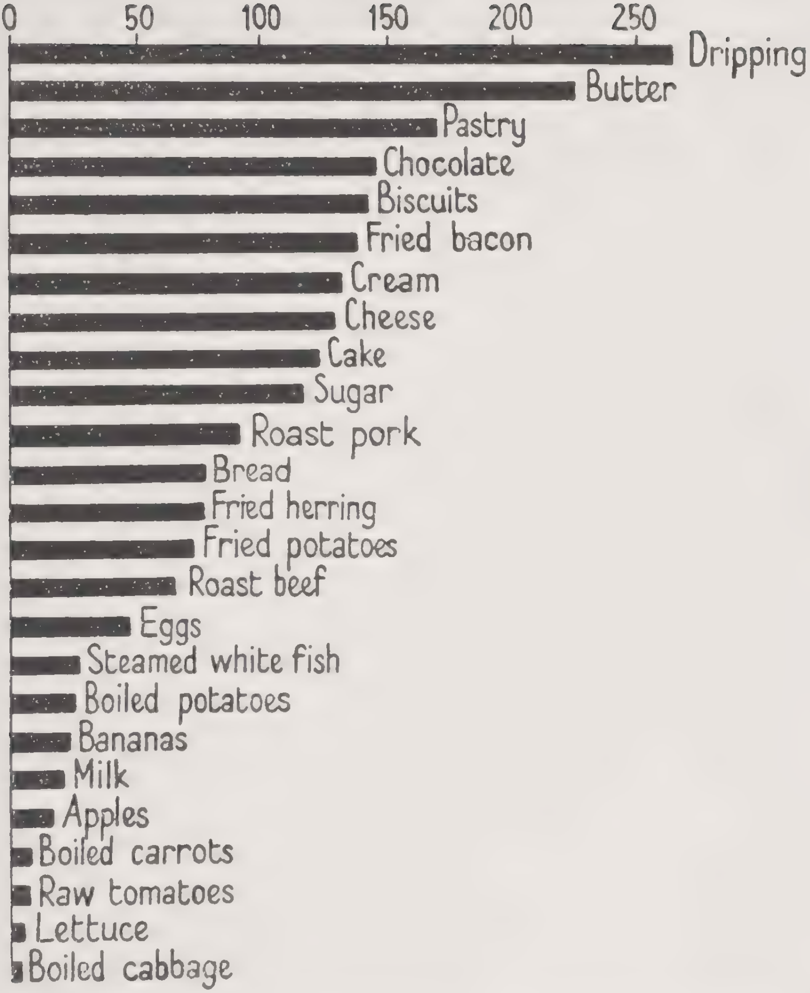


FIG. 3. Diagram showing the calorie value of one ounce of some common foods (edible portion only).

nearly 60 per cent. of water. Water has no calorie value at all; it cannot be burnt since it is already fully oxidized. Foods that contain a great deal of water therefore have low calorie values. This accounts for the very low calorie values of fruit and vegetables; even dried peas and beans, when boiled, yield only about 30 calories an ounce, boiled potatoes yield about 25, apples 13, and boiled cabbage only 2 or 3. Fried vegetables, however, have higher calorie values because foods absorb fat while being fried. The calorie value of fish, like that of meat, depends on how much fat is present. Steamed white fish, which has nearly 80 per cent. of water, about 18 per cent. of protein, and not much fat, yields only about 25 calories per ounce; but fatty fish such as herrings yield two or three times this amount. Cheddar cheese yields 120 calories per ounce, eggs nearly 50, and milk about 20.

The calorie value per ounce of a number of foods is given in the tables on pages 158 to 170, and a few of these values are given graphically in Fig. 3, p. 41.

CHAPTER IV

VITAMINS AND THEIR HISTORY

It has long been an axiom of mine that the little things are infinitely the most important.

CONAN DOYLE.

AT the end of the nineteenth century and for some years afterwards, great emphasis was laid on the calorie value of food. To most physiologists it seemed as though the whole problem of nutrition resolved itself into a determination of the number of calories required in diets and the correct proportion of protein, carbohydrate, and fat. Mineral elements were known to be necessary but were not emphasized. Vitamins had not been discovered.

But evidence was gradually accumulating that man cannot live by calories alone. The idea was gaining ground that ordinary diets contained some other essential nutrient in addition to those already discovered. Research workers in several countries found that laboratory rats and mice were unable to grow if they were fed on food mixtures containing all the known nutrients in a highly purified state. The pioneers in this field included Lunin in Switzerland (1881), Osborne and Mendel in the U.S.A. (1911), and Stepp in Germany (1911).

In 1912 further evidence was brought forward by Sir Frederick Gowland Hopkins. His experiments were simple but convincing. He fed a series of young rats on an artificial food mixture containing suitable proportions of highly purified protein, carbohydrate, fat, water, and mineral salts. The rats soon stopped growing and then began to lose weight. At the same time a second series of young rats was fed on an exactly similar purified diet with the addition of a trace of fresh milk. The amount of milk added was not enough to have an appreciable effect on the calorie value of the diet, but it had a striking effect on growth, for these rats gained steadily in weight. In order to complete the proof of the value of the added milk, the diets were then reversed. The rats that had been losing weight on the purified diet were given a trace of milk in addition to their former rations, and after a few days they began to grow in a normal way. The rats that had been gaining weight on the diet with added milk were given only the purified diet, and they stopped growing almost at once (see Fig. 4). From these results Sir Frederick

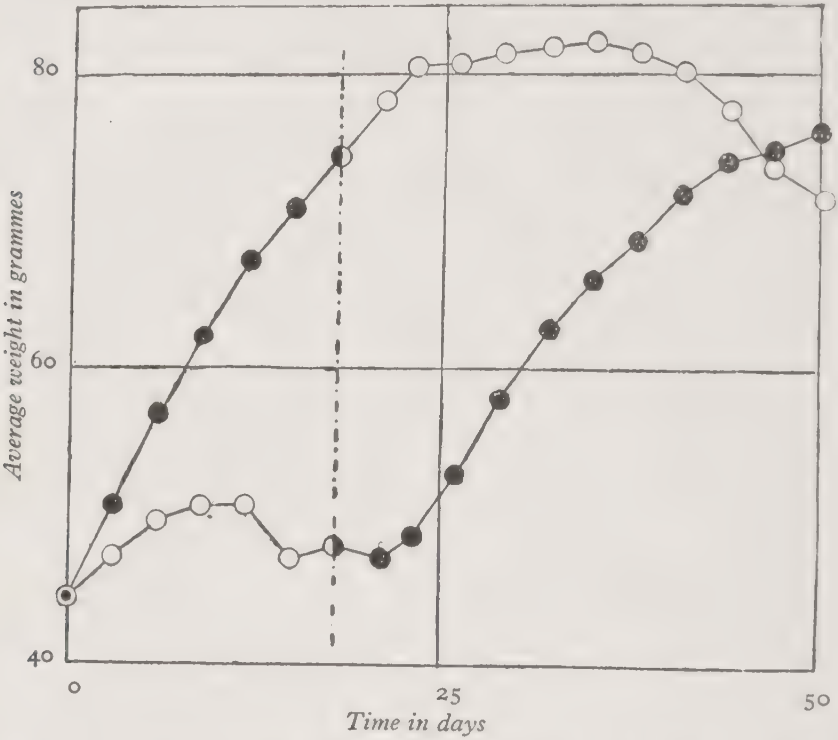


FIG. 4. Growth curves showing the inadequacy of a diet of purified protein, fat, carbohydrate, mineral salts, and water, and the beneficial effect of added milk.

The lower curve (up to the 18th day) shows the average weight of 8 male rats on a diet of purified protein, fat, carbohydrate, mineral salts, and water; the upper curve shows the average weight of 8 similar rats on the same diet with added milk. On the 18th day (dotted line) the diets were reversed. (From 'Feeding Experiments illustrating the Importance of Accessory Factors in Normal Dietaries', by F. G. Hopkins, *Journal of Physiology*, 1912, vol. 44, p. 425.)

Hopkins concluded that milk contains 'accessory food factors' which are essential for normal growth.

Observations of another kind also indicated the existence of unrecognized but essential food constituents. One or two medical men were beginning to suspect that certain diseases were caused by the lack of some such nutrient. As early as 1897 Eijkman, a Dutch physician working in Java, showed that the disease of beri-beri was due to the absence of some unknown food constituent, and could be cured by adding to the diet the special substance concerned. Ten years later Holst and Frölich in Norway discovered that scurvy could be prevented by another unknown constituent of food.

It was Sir Frederick Gowland Hopkins who first pointed out the connexion between these two independent sets of observations. He realized that the unknown constituents of food which were essential for normal growth were the same kind of substances as those which were able to cure such diseases as scurvy and rickets. He made this important suggestion in 1906, and repeated it in 1912 when he published the experiment described above. In 1912 Casimir Funk, a Polish biochemist working in London, brought forward a similar theory of the origin of deficiency diseases.

In 1915 in the U.S.A. Dr. McCollum and Miss Davis showed that there were at least two different accessory food factors, one insoluble in water and associated with fats and the other soluble in water. They suggested the names 'fat-soluble A' and 'water-soluble B' for the two substances, thus starting the alphabetical terminology that has been found so useful ever since. The word 'vitamine', first spelt with a terminal 'e', was provided by Funk, who used it in 1912 for the substance concerned in curing beri-beri; later it was extended to include all the other organic accessory food factors as well. In 1920 the spelling was altered to 'vitamin' at the suggestion of Sir Jack Drummond, because it had been found that these substances did not all contain the special group of atoms known as the amine group. Indeed, up to the present time, the only vitamin that has been found to contain an amine group is vitamin B_1, the original 'vitamine' of Funk.

The most striking feature of the vitamins as a class is that the amount necessary for health is exceedingly small compared with the total daily ration of food; yet this small trace of vitamins makes all the difference to the proper working of our bodies. Moreover, deficiencies of vitamins may lead to actual disease. This conception is now perfectly familiar, but thirty years ago it was regarded as revolutionary. Ever since Pasteur's famous discoveries, disease had been so constantly associated with positive agents, such as bacteria and toxins, that it was hard to convince people that the mere lack of something could lead to a pathological condition.

The question of daily allowances of vitamins will be considered in the next chapter. Here we shall deal with the history and significance of vitamin A, vitamin B_1, riboflavin, nicotinic acid, vitamin C, and vitamin D. Vitamin E and vitamin K will be mentioned very briefly.

Vitamin A

Fat-soluble A, the accessory food factor originally discovered in milk by Sir Frederick Hopkins, was later found to consist of two separate components. These were named vitamin A and vitamin D (since the letters B and C had already been appropriated). Both are associated with fats in food and are therefore said to be fat-soluble. First of all we will consider vitamin A.

When diets are deficient in vitamin A, the delicate mucous membranes inside the body tend to dry up and break, thus allowing harmful bacteria to gain entrance to the tissues. People who do not obtain enough vitamin A are therefore liable to suffer from infections of the mucous membranes, such as respiratory diseases, ear and sinus infections, inflammation and infection of the alimentary canal. Since vitamin A deficiency is so often correlated with infection of some kind, this vitamin was at one time thought to be anti-infective in action, and it was called the anti-infective vitamin. This name has been given up, however, as it has been found that there are a number of infections which vitamin A cannot cure. Its anti-infective powers are merely due to the fact that it keeps the mucous membranes of the body in proper working order.

Night-blindness. The earliest symptom of vitamin A deficiency is night-blindness. Vitamin A is necessary for the formation of a substance known as visual purple, which occurs in the retina of the eye. In normal people, visual purple is bleached by light and quickly regenerated. But in people who are suffering from a slight lack of vitamin A, it takes a longer time for the visual purple to be regenerated; the result is that they suffer from night-blindness, that is to say, they cannot see properly in a dim light. Night-blindness is not a serious disorder, but it is a handicap to motorists, cyclists, and pedestrians who have to go out in the dark. It should be mentioned that lack of vitamin A is by no means the only cause of night-blindness.

Xerophthalmia. A serious eye disease, xerophthalmia, may develop if the diet lacks vitamin A. This disease is particularly apt to occur in breast-fed babies whose mothers do not obtain enough vitamin A. For instance, in Denmark in the early years of World War No. 1, there was an increase in the incidence of xerophthalmia among infants whose mothers ate margarine (which in those days was not 'vitaminized' and contained no vitamin A) instead of butter (which contains vitamin A). During 1918 and 1919, however, butter was rationed in Denmark and eaten by everyone, with the result that there were fewer cases of xerophthalmia among infants (13 cases in 1918–19 compared with 149 cases in 1916–17). Although xerophthalmia is practically unknown in this country, it is one of the chief causes of blindness in China, India, Ceylon, Malaya, and Sumatra.

Vitamin A and carotene. The early work on vitamin A showed that it occurred in milk-fat, butter, cod-liver oil, and certain other animal fats, but not in olive oil or the vegetable fats used in the manufacture of margarine. Then in 1919 Dr. Steenbock of Wisconsin discovered that carrots, yellow maize, and a number of other plant products contained either vitamin A or something very similar. Curiously enough, the yellower they were, the more vitamin A activity they had; indeed, their activity turned out to be due to the pigment that gives them their orange or yellow colour. This was very puzzling since this orange-yellow pigment, carotene, was not the same chemical compound as the colourless vitamin A. But it was found later that the two substances are intimately related. The carotene molecule (a complicated hydrocarbon with the formula $C_{40}H_{56}$) consists of two loosely united vitamin A groups, less two molecules of water. The formula of vitamin A is thus $C_{20}H_{29}OH$. When we eat carotene, it is changed into vitamin A in the body, and carotene is therefore known as pro-vitamin A.

Carotene, however, is not so well utilized in the body as vitamin A itself, and therefore a larger amount is necessary if it is taken in this form. Oddly enough, carotene was isolated from carrots as long ago as 1831, but its importance in nutrition remained unknown for eighty-nine years. There are a number of substances known as carotenoids which resemble carotene, and which also act as pro-vitamin A. All these, like carotene and vitamin A itself, are insoluble in water but soluble in fats.

Sources of vitamin A and carotene. In this country we are unlikely to suffer from serious shortage of vitamin A, but slight deficiencies should be guarded against by eating foods rich in either vitamin A or carotene (see pp. 148–149). The richest sources of vitamin A itself are fish-liver oils, such as halibut-liver oil and cod-liver oil. Halibut-liver oil is considerably richer than cod-liver oil in this respect, and some fish-liver oils are far richer still. Fish-liver oils should be kept in light-proof bottles, because they lose their vitamin A if they are exposed to sunlight. Other good sources of vitamin A are liver (from the ox, sheep, or pig), cheese, eggs, and also summer milk, cream, and butter; vitaminized margarine contains added vitamin A (and D). Cooking has no effect on vitamin A.

Carotene, as its name implies, occurs in carrots. In addition it is found in other yellow- and orange-coloured vegetables, fruits, and cereals, such as tomatoes, apricots, peaches, oranges, sweet potatoes, pumpkin, squash, and yellow maize. There is carotene also in green vegetables such as kale, cabbage, and lettuce, and the amount of carotene goes hand in hand with the amount of chlorophyll, the green colouring matter of plants; dark green leaves of cabbage, &c., are rich in both chlorophyll and carotene, but pale etiolated inner leaves contain little or none of either. Fortunately, cooking does not destroy carotene; indeed there is some evidence that more carotene is absorbed from cooked carrots than from raw ones.

Milk, butter, and cheese contain both carotene and vitamin A itself, and the total amount of both is here known as the 'vitamin A activity'. This varies with the diet of the cow. Grass is rich in carotene, and in summer when cows eat grass the 'vitamin A activity' of the milk is at a maximum. But in winter if the cow has the usual dry feed of cereals and roots, the 'vitamin A activity' of the milk goes down. Winter milk can, however, be made richer in this respect if the cows are given food that contains plenty of carotene. For this purpose carrots are very good, and a special type of ensilage made from artificially acidified green fodder is used with great success in Finland. Hay is poor, but it is possible to dry young grass in such a way that it contains almost as much carotene as fresh grass. If cows are fed on this special dried grass, the winter milk will have as rich a colour and as high a 'vitamin A activity' as summer milk. Cheese is usually made in summer and therefore has a high 'vitamin A activity'.

The Vitamin B Complex

The original vitamin B is now called the 'vitamin B complex', since it has turned out to contain a number of different vitamins. We shall consider only three of these—vitamin B_1, riboflavin, and nicotinic acid. Diets that contain adequate amounts of these three vitamins will probably also contain as much as we need of the other vitamins in the vitamin B complex.

Vitamin B_1

Beri-beri. Long before the discovery of vitamins, it was suspected that the disease of beri-beri was in some way connected with diet, but the exact nature of the connexion was not quite clear. Beri-beri is a disorder of the nervous system that results in a special type of neuritis. It used to be very common in such countries as China, Malaya, Java, and Japan, where rice is the staple foodstuff. In 1893–7 Eijkman, the medical officer of the prison at Java, had a number of cases of beri-beri under his care, and he noticed the remarkable fact that the hens in the prison yard had symptoms of paralysis like those of his beri-beri patients. Since the hens, like the patients, lived on polished rice, it looked as if the diet might be responsible for the disease. Eijkman found that beri-beri occurred if the rice was 'polished' but not if it was in the crude unpolished state. When rice is machine-milled according to the usual present-day method, the outer layers or 'polishings' of the rice-grain are removed, and Eijkman found that beri-beri could be prevented by adding the discarded rice 'polishings' to the diet. At first it was thought that the role of the 'polishings' was to neutralize the deleterious effect of a diet too rich in starch, but further work showed that the curative effect was due to the presence of a vitamin.

It was then found that the anti-beri-beri vitamin (or anti-neuritic factor as it was then called) was identical with water-soluble B (later known as vitamin B). But the original vitamin B, as we have said, turned out to be a mixture of several vitamins, and the anti-neuritic substance was therefore given the name of vitamin B_1 in this country; in the U.S.A. it was called simply vitamin B. Nowadays it is usually called aneurin (a contraction of anti-neuritic vitamin) in this country and thiamine in the U.S.A.

Although beri-beri is chiefly confined to countries where rice forms the bulk of the diet, there have been occasional outbreaks in western Europe. For instance, beri-beri once broke out in Norwegian merchant ships. Before 1894 the food had consisted mainly of rye biscuit, which contained ample vitamin B_1, and beri-beri rarely occurred. But in 1894 there was a popular agitation to lessen the hardships of sailors' lives, as a result of which the rye biscuit was largely replaced by white bread. Unfortunately this led to many cases of beri-beri, because white bread is deficient in vitamin B_1. It may be wondered why there was no beri-beri among the white-bread eaters of pre-war England. The reason is that these people had a mixed diet, containing a good many other sources of vitamin B_1. At the same time, although beri-beri itself does not often occur, it is quite possible that there may be a slight shortage of vitamin B_1 in some diets even in this country.

In rice-eating countries, the best way to stamp out beri-beri seems to be to parboil the rice before milling it. Parboiling consists in steaming the rice in the husk. In parts of India where rice is treated in this way, there is no beri-beri. During the parboiling, the soluble vitamin B_1 diffuses from the 'germ' into the inner portion of the rice grain, and it is therefore not removed when the outer parts of the grain are removed during the subsequent 'polishing'.

Composition of vitamin B_1 (*aneurin*) *and its functions.* Vitamin B_1, like the other vitamins, occurs in such exceedingly small amounts in food that it is very difficult to obtain in a pure state. By 1926, however, a highly active preparation had been isolated, and ten years later vitamin B_1 was produced synthetically in the laboratory. The chemical formula is $C_{12}H_{17}ON_4SCl.HCl$, and the molecule contains two complicated ring structures (pyrimidine and thiazole). Vitamin B_1 is part of the enzyme system that is concerned with the oxidation of carbohydrates in the body. For this reason, people should have an extra supply of vitamin B_1 if their diet includes a particularly large amount of carbohydrate. On the other hand, less vitamin B_1 is needed by people who eat relatively small amounts of carbohydrate.

Sources of vitamin B_1. There is a small amount of vitamin B_1 in most foods, unless they have been subjected to a refining process. Those especially rich in this vitamin include yeast, the 'germ' of cereals, peas, beans, pork, ham, bacon, liver, and kidney (see also pp. 150–151). The actual distribution of the vitamin B_1 in the wheat grain is very important. The largest amount occurs in a special layer of the 'germ' (known as the scutellum), and there is a certain amount in the bran, but the endosperm, which occupies most of the grain, contains practically none (see also p. 86, and Fig. 6, p. 85). Brown flour and National (85% extraction) flour both contain a good deal of vitamin B_1, but white flour contains very little, because both bran and 'germ' are removed during milling, just as they are with polished rice. Since vitamin B_1 is readily soluble in water, it tends to be washed out of foods that are cooked in water; moreover it is destroyed to some extent by heat, especially in the presence of alkalies, such as cooking-soda.

Besides being obtained from many foods, vitamin B_1 can be synthesized by the bacteria in the intestine of certain animals including rats, cows, and human beings too. But it is not yet certain how much use human beings can make of the vitamin B_1 produced in this way.

Riboflavin

Riboflavin, which was originally called vitamin B_2 in England and vitamin G in the U.S.A., is one of the components of the vitamin B complex. It is an orange-yellow substance composed of a sugar (ribose) and a pigment (flavin). The chemical formula is $C_{17}H_{20}N_4O_6$. It dissolves in water, giving a solution with a greenish-yellow fluorescence. The fluorescence of whey is due to riboflavin, and indeed riboflavin was isolated in an impure form from whey in 1879, but no one knew it was a vitamin until 1933.

Riboflavin, like vitamin B_1, is part of the enzyme system that deals with the oxidation of carbohydrates, and more riboflavin is therefore needed when the amount of carbohydrate in the diet is increased. An extra supply of riboflavin is also needed by airmen and other people who are exposed to very bright light, since this vitamin is destroyed by light. There is no definite name for the condition associated with riboflavin deficiency. The early symptoms include an affection of the eyes and a scaly condition at the corners of the mouth.

The best sources of riboflavin are yeast, liver, milk, and eggs (see also p. 152). Peas, beans, and the grains of cereals contain only a small amount of riboflavin in the dry state, but if they are moistened and allowed to germinate for a few days they become a richer source of this vitamin. Malt, which is dried germinated barley, contains riboflavin, and even beer contains a small amount. In the wheat grain, the concentration of riboflavin is highest in the 'germ' and lowest in the endosperm, the bran being intermediate (see also p. 86). When food is cooked, a small amount of the riboflavin is destroyed by the heat, and a good deal diffuses out of the food if it is cooked in water, since riboflavin is soluble in water. Riboflavin, like vitamin B_1, appears to be synthesized to some extent by bacteria in the human intestine.

Nicotinic Acid

Nicotinic acid protects us against pellagra, a disease which is rare in northern Europe, but which is a terrible scourge in places where maize is the staple foodstuff. There is a certain amount of pellagra in Italy, Rumania, Spain, Portugal, and Africa, and a great deal in the southern part of the U.S.A. The word 'pellagra' means rough skin, and pellagrins (as the victims of the disease are called) suffer from a peculiar type of inflammation of the skin.

Pellagra is nearly always associated with very poor diets.

It was once thought to be due to amino-acid deficiency, since zein, the chief protein of maize, lacks two of the essential amino-acids (tryptophane and lysine). But Dr. Goldberger, working in the U.S.A., found that yeast and several other foods contained a vitamin-like substance which was capable of curing pellagra. He called this the P-P (pellagra-preventive) factor. This factor, which was part of the vitamin B complex, was once thought to be identical with vitamin B_2 or G (now known as riboflavin), but later work showed that this was not so. The P-P factor was finally run to earth during the investigation of a disease of dogs called 'black-tongue', which was thought to be related to pellagra. An American worker found that black-tongue could be cured by nicotinic acid. English workers then managed to produce pellagra experimentally in a pig and cured it with nicotinic acid, and other workers in the U.S.A. cured human pellagrins in the same way.

Nicotinic acid, a derivative of the nicotine of tobacco, has been known to organic chemists ever since 1867, but it was not recognized as a vitamin until 1938. Like quinine and cocaine, it is an alkaloid. Nicotinic acid contains a ring of atoms called the pyridine ring, and has the chemical formula C_5H_4NCOOH. Actually the acid itself is a pro-vitamin, the real vitamin being nicotinamide ($C_5H_4NCONH_2$). Nicotinic acid is called niacin in the U.S.A. to avoid confusion with the nicotine of tobacco. It may be mentioned that smoking does not provide us with any nicotinic acid.

The richest sources of nicotinic acid include yeast, meat, fish, barley, and wheat; potatoes and beer provide a small amount (see also p. 153). In the wheat grain, the highest concentration of nicotinic acid occurs in the outer layers (the bran, including the aleurone layer), and the lowest in the endosperm; the 'germ' is intermediate (see also p. 86). Oatmeal and rye are poor in nicotinic acid; both contain less than whole maize, and oatmeal even contains less than maize-meal (cornmeal) that has had the 'germ' removed. The nicotinic acid of grains, peas, and beans, is considerably increased by germination, just as the riboflavin is, and both malt and beer contain nicotinic acid. Cooking has not much effect on nicotinic acid, but it is soluble in water and therefore tends to be washed out of food that is cooked in water. With nicotinic acid, as with vitamin B_1 and riboflavin, the requirement increases when the amount of carbohydrate in the diet increases, since this vitamin too is part of the same enzyme system.

Apparently nicotinic acid is synthesized by bacteria in the human intestine, in the same way as vitamin B_1 and riboflavin, but here again it is not certain whether this has any effect on human requirements or not. Some investigators, however, consider that we obtain a large proportion of our total nicotinic acid from bacterial synthesis, and that it is therefore difficult to say how much of this vitamin we require from food; they believe, moreover, that the type of food eaten affects the amount of nicotinic acid synthesized by intestinal bacteria, some foods favouring the growth of the special bacteria more than others.

Vitamin C

Scurvy. Scurvy is a disease which, like beri-beri, has long been attributed to faulty diets. Seafaring folk have known for centuries that scurvy developed if fresh food was absent from the diet for a long time, and until fairly recently scurvy was the common dread of all sailors. Soldiers and explorers also suffered terribly from scurvy. During Jacques Cartier's second voyage to Newfoundland in 1535, 100 of his 103 men developed scurvy, and 25 of them died. Babies are also liable to suffer from this disease, and infantile scurvy (Barlow's disease) was formerly not unusual among babies fed on artificial foods.

Fresh fruit and green vegetables have often been recommended as a cure. For instance in Lind's *Treatise of the Scurvy*, published in 1753, there is the following account of the conclusions of an Austrian army surgeon:

> The scurvy is the most loathsome disease in nature; for

> which no cure is to be found in your medicine-chest, no not in the best-furnished apothecary's shop. Pharmacy gives no relief, surgery as little. Beware of bleeding; shun mercury as a poison: you may rub the gums, you may grease the rigid tendons in the ham, to little purpose. But if you can get green vegetables; if you can prepare a sufficient quantity of the fresh noble antiscorbutic juices; if you have oranges, lemons, or citrons; or their pulp and juice preserved with sugar in casks, so that you can make a lemonade, or rather give to the quantity of three or four ounces of their juice in whey, you will, without other assistance, cure this dreadful evil.

Navigators constantly noted the curative effect of oranges and lemons, and in 1804 a regular issue of lemon juice was made compulsory in the British Navy; after this scurvy became rare, although there had previously been thousands of cases every year.

The final proof that scurvy is a deficiency disease, caused by the lack of some substance that occurs in fresh fruit and vegetables, was provided by Holst and Frölich in 1907–12, and some years later the anti-scurvy (anti-scorbutic) factor was given the name of vitamin C.

Pure vitamin C (ascorbic acid). In 1932 it was found that the chemical composition of vitamin C was exactly the same as that of a substance called hexuronic acid, which had been isolated from oranges and cabbages by the Hungarian biochemist, Professor A. Szent-Györgyi, four years earlier. The old name, hexuronic acid, was then changed to ascorbic acid, a contraction of anti-scorbutic acid. It has now been found that ascorbic acid is not an acid. It has the chemical formula $C_6H_8O_6$, and is chemically related to the sugars. It can be prepared synthetically in the laboratory from galactose.

Sources of vitamin C. By far the most important sources of vitamin C are fruits and vegetables. Rich sources include black-currants, rose-hips, oranges, lemons, grapefruit, strawberries, gooseberries, kale, parsley, Brussels sprouts, cauliflower, cabbage, new potatoes, and swedes (see also pp.154–155). Other plant products rich in vitamin C include the peel of citrous fruits, nasturtium leaves, green walnuts, fresh paprika, and pine needles. There is no vitamin C in legumes or grains in the dry state, but a considerable amount develops if they are moistened and left to germinate for a few days. Animal products provide us with little or no vitamin C, though there is a certain amount in milk fresh from the cow, and in meat (especially liver) immediately after the animal has been killed. But milk has lost a good deal of its vitamin C by the time it is delivered to the consumer, and meat contains only a negligible amount of vitamin C by the time the animal has been bled and the meat stored and cooked.

Destruction of vitamin C during storage, food preparation, and cooking. Unfortunately vitamin C is most unstable. In fruits, the acidity protects the vitamin C to some extent, but in vegetables there are often considerable losses. These losses will be considered in detail later, but the causes of loss will now be briefly discussed. In plant tissues, side by side with the vitamin C there is an enzyme called an oxidase which destroys vitamin C. When plant tissues are alive and undamaged the oxidase remains apart from the vitamin, but if the cells are damaged the oxidase gains access to the vitamin and destroys it. This is why vegetables fresh from the soil contain more vitamin C than those which have been stored, for some of the plant cells are destroyed during storage. The oxidase also destroys vitamin C rapidly when green vegetables are grated, since this damages the cells considerably; if green vegetables are cut with a sharp knife, however, fewer cells are damaged and there is far less destruction of vitamin C. Even during cooking, the oxidase may exercise its destructive action, since it works very well at moderately warm temperatures, but it is itself destroyed when vegetables are immersed in boiling water, if the vegetables are small or have been cut up into thin slices so that the heat can penetrate rapidly. When vegetables are steamed, it takes some time for them to warm up, even if the steamer is hot to start with; the result is that the oxidase is able to destroy a good deal of vitamin C before it is itself destroyed. Steaming also has the disadvantage of being a slow method of cooking, which is bad because heat itself destroys vitamin C, especially if it is prolonged. Since vitamin C is soluble in water, it is readily washed out of boiled vegetables and stewed fruits, and the greater the volume of cooking water, the greater the amount of vitamin C washed out. Another cause of loss is oxidation by the oxygen of the air; this is greatly accelerated by heat, and is a serious cause of loss when cooked vegetables are kept hot after being strained. Drying also destroys vitamin C, unless it is carried out by the new process of dehydration.

Vitamin D

Rickets. Rickets is one of the most ancient of diseases. A distinguished pathologist remarked that his enjoyment of Italian art was spoilt because he so often recognized the symptoms of rickets in the babies painted by the great Florentine masters. These symptoms were well known to the physicians of long ago and are described in very early manuscripts. Indeed there is evidence from skeletons that even prehistoric man suffered from rickets. Nowadays rickets still occurs, although serious cases resulting in bow-legs and knock-knees are happily less common than milder forms of the disease.

Only within recent years have we known that rickets is due to vitamin deficiency. Previously there were many different theories about its cause. In this country some doctors blamed unhygienic conditions. This view gained considerable support from the results of investigations carried out in large cities, for rickets was rife among children who lived in crowded unwholesome surroundings, but not where housing conditions were better. Other doctors considered that faulty diets were responsible. Since calcium is an important constituent of bone, the defective bone formation characteristic of rickets was frequently thought to be due to lack of calcium, and lime-water was recommended as a cure. Other investigators supposed that rickets was due to an excess of carbohydrate (cereal) in the diet; and another idea, based chiefly on work with lion cubs at the Zoo, was that rickets was due to deficiency of fat.

As early as 1906, however, Sir Frederick Hopkins suggested that rickets might be due to the deficiency of what we now call a vitamin, and in 1919 Sir Edward Mellanby proved that this was indeed the case. Sir Edward Mellanby worked with puppies, and found that both butter and cod-liver oil contained an anti-rachitic (anti-rickets) substance which protected the puppies from rickets or cured the disease if given in time. The anti-rachitic substance was at first thought to be the same as fat-soluble A, but Dr. McCollum and his colleagues showed that the two vitamins are not identical, although they occur together in several foods, for instance, cod-liver oil. The original fat-soluble A was therefore separated into vitamin A and the anti-rachitic vitamin D.

The role of sunlight. Although it was clear from Sir Edward Mellanby's work that vitamin D was able to prevent or cure rickets, there was a certain amount of evidence that sunlight also played a part. It had long been known that rickets never occurred in the tropics, and that even in England it was less common in summer than in winter. Then in 1919 Huldschinsky managed to cure rickety children in Germany by exposing them to ultra-violet rays, produced by a quartz mercury-vapour lamp. Later, in the U.S.A., Dr. Hess obtained similar results with sunlight, which owes this action to its ultra-violet rays. This led to the extraordinary conclusion that exposure to ultra-violet light had the same effect as the addition of vitamin D to the diet. Apparently rickets could be cured either by sunshine or by cod-liver oil.

Dr. Harriette Chick and her colleagues from the Lister Institute, London, confirmed this in 1920 by their work on the starving children of Vienna. These investigators found that rickety children could be cured by cod-liver oil, or by exposure to either sunlight or ultra-violet rays. Less cod-liver oil was needed if sunlight was also available, but sunlight could not effect a complete cure in serious cases unless the diet contained a certain amount of vitamin D. On the other hand, vitamin D could prevent or cure rickets even in the absence of sunlight.

Unfortunately, sunlight loses its anti-rachitic power when it passes through ordinary glass, because the ultra-violet rays are absorbed. Special glass can be obtained through which the curative rays can pass, if the glass is clean but not otherwise. Windows made of this glass are useful for hospitals, though little or no benefit is derived by the patients unless they are near to the window. It is better for people who can do so to go out of doors to obtain their ultra-violet light, for in this way they obtain far more of it and have the added benefit of the fresh air. In warm weather babies should be freely exposed to sunlight, but their eyes should be protected. As might be expected, sunlight affects the anti-rachitic power of cow's milk. Cows kept out in the fields supply milk containing more vitamin D than do those kept all day long indoors.

The role of sunlight in rickets was difficult to explain until it was discovered that certain foods, which did not originally contain the anti-rachitic substance, developed it after exposure to ultra-violet light. For instance, vegetable oils when irradiated acquire anti-rachitic power. Moreover, the anti-rachitic power of milk can be greatly increased by treating it with ultra-violet rays. At one time it was thought that even air developed anti-rachitic properties when it was irradiated. In one experiment laboratory rats remained free from rickets when they were kept in perfect darkness, but only if the air of the room had previously been exposed to sunlight. In other experiments, however, the rats began to show signs of rickets even when they were kept in the so-called 'tonic air', and it was found that they only escaped rickets if the irradiated cages contained sawdust. It was the sawdust and not the air that acquired curative properties. Experiments were then set up to see whether sawdust gave out some mysterious emanation which was responsible for the anti-rachitic effect, but no such emanation could be discovered. It finally turned out that the rats only benefited from the irradiated sawdust when they ate it!

Ergosterol and calciferol. The next step was to find out what particular constituent of sawdust, milk, &c., was changed by irradiation. This was found to be a wax-like substance called cholesterol. It seemed as though vitamin D might be simply irradiated cholesterol. Further research, however, showed that it was not cholesterol itself which became activated, but ergosterol—a substance present in minute amounts in what had previously been thought to be pure cholesterol. This impurity had remained unnoticed before because it occurred to the extent of only one part in two thousand. When ergosterol is irradiated it acquires the property of preventing or curing rickets. The irradiation, however, results not in one substance but in a mixture. From this, an extremely active substance has been isolated, and it has been named calciferol, on account of its calcifying action on bones and teeth.

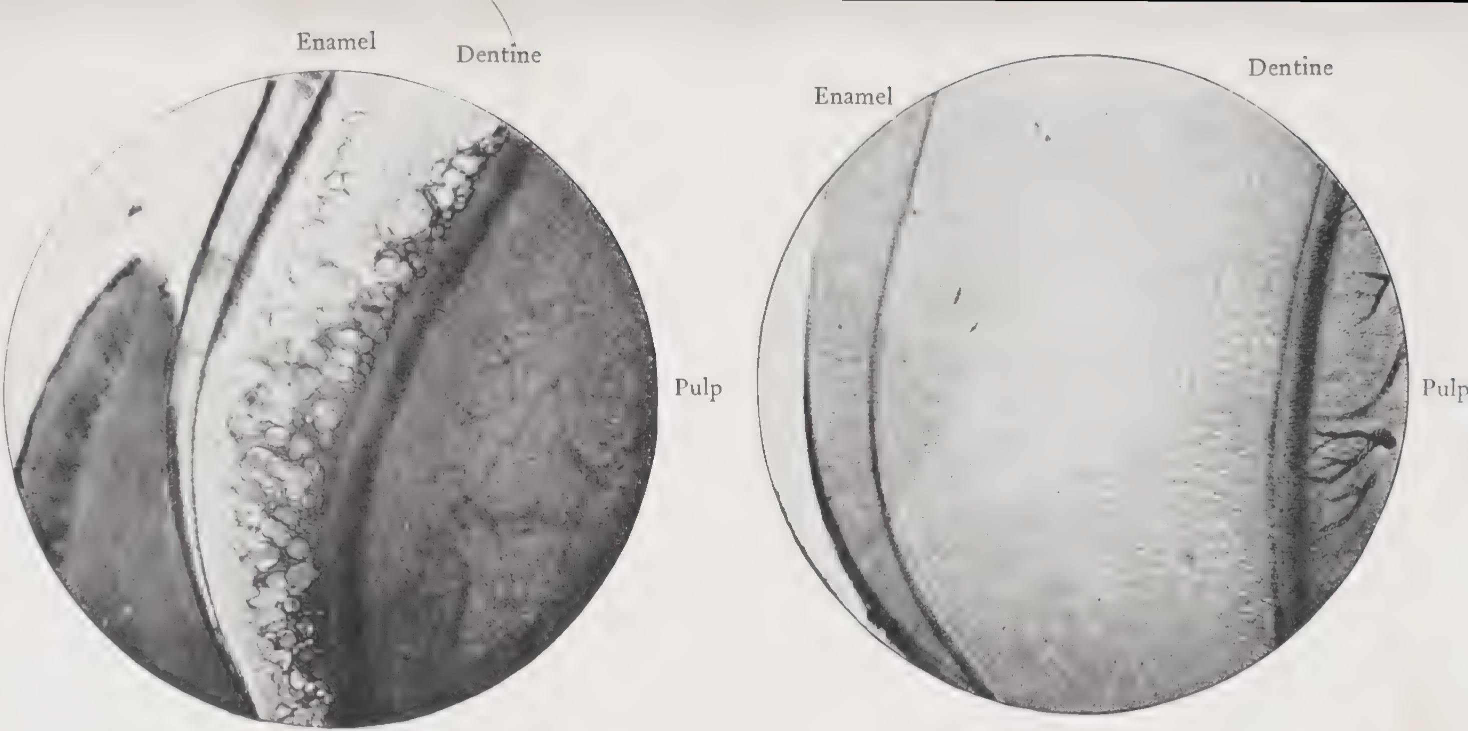
Calciferol is a complicated member of the series known in chemistry as the alcohols (alcohol itself is a simple member of this series) and has the chemical formula $C_{28}H_{43}OH$. It is amazingly active: less than half an ounce is enough to supply the daily ration of vitamin D for a lifetime. Curiously enough, calciferol is slightly different from the naturally occurring vitamin D of fish-liver oils. Moreover, there are other sterols besides ergosterol that acquire anti-rachitic properties when they are irradiated. These substances, like the vitamin D of fish-liver oils, are all soluble in fat and insoluble in water.

Osteomalacia. Adults who have not enough vitamin D in their food, and who live under sunless conditions, suffer from softening of the bones, or osteomalacia. Cases are sometimes found in India among women who live in purdah.

Bad teeth. The researches of Lady (May) Mellanby have shown that lack of vitamin D is frequently associated with bad teeth. Lady Mellanby found that puppies with rickets had badly formed teeth (see Fig. 5), and in 1918 she made the important suggestion that the diseased condition of many children's teeth might be due to imperfect tooth formation, brought about by malnutrition. This idea was criticized by some dentists, who said that only 3 per cent. of the first (deciduous) teeth of children were badly formed, whereas 90 per cent. of them ultimately decayed. Lady Mellanby, however, made a microscopic examination of over 2,000 deciduous teeth, and found that not 3 per cent. but about 80 per cent. were imperfectly calcified. These badly formed teeth had a roughish surface and more often showed signs of decay than did teeth with a comparatively smooth surface and properly formed dentine and enamel. Later, Lady Mellanby found that tooth decay could be checked to some extent even in badly formed teeth by a diet of high calcifying power, that is, a diet containing adequate amounts of calcium, phosphorus, and vitamin D. Cereal products, however, were found to hinder calcification.

Sources of vitamin D. Unfortunately very few foods contain vitamin D. Indeed, when we look down the appropriate column of the food tables on pages 158 to 170 and see the noughts, we are not surprised that vitamin D deficiency occurs so often. It is true that if the sun is shining we can make our own vitamin D if we wish: but in a temperate climate there may not be enough sunshine to provide children with as much vitamin D as they require.

By far the largest natural source of this vitamin is the liver oil of certain fishes, such as halibut and cod. Halibut-liver oil is about twelve times as rich as cod-liver oil in this respect, and the liver oils of tunny-fish and some other fish are far richer still. These oils vary somewhat in potency, but even the least potent sample of cod-liver oil contains much more vitamin D than any other kind of food. The next best natural source is fatty fish, such as tinned sardines, herrings, mackerel, and tinned salmon (see also p. 156). Other



(*a*) Section of tooth from puppy fed on diet deficient in Vitamin D

(*b*) Section of normal tooth

FIG. 5. Photomicrographs of sections of teeth showing the effect of cod-liver oil on tooth formation.

From 'The Effect of Diet on the Structure of Teeth', by May Mellanby, *British Dental Journal*, 1923, vol. 44, p. 1031.

sources are eggs, summer butter, vitaminized margarine, dripping, and cheese. Milk contains very little vitamin D even in summer. There is no vitamin D in plant products. Cooking has no effect on this vitamin.

There are several concentrated preparations of vitamin D on the market, some of which contain other vitamins as well. These are convenient for certain cases, but it is better to use fish-liver oils whenever possible. With cod-liver oil there is practically no risk of obtaining too much vitamin D, and there is always the possibility that some important but unknown food constituent may be provided as well as vitamins A and D. Halibut-liver oil has the advantage that only a very small daily dose is required because it is so potent. When commercial preparations of vitamin D are used, great care should be taken to avoid an overdose. Large overdoses, six or seven times the correct dose, are toxic and may have serious effects.

Cereals and rickets. It has often been noticed that cereal products, especially oatmeal, seem to favour rickets. Sir Edward Mellanby found that more vitamin D was needed to protect his puppies from rickets if they were fed on oatmeal than if the oatmeal was replaced by white bread or rice, and he suggested that oatmeal might contain an anti-calcifying substance or ‘toxamin’. Other workers have found that this anti-calcifying substance is phytic acid, a phosphorus compound which is not at all well utilized in the body, and which has the annoying habit of precipitating some of the calcium from our food and rendering this unavailable too. Phytic acid thus has a direct anti-calcifying action, rather than the ‘toxamin’ action that was first suggested. Foods rich in phytic acid lead to calcium deficiency, unless the diet contains an ample supply of calcium. This explains why oatmeal predisposes puppies to rickets, for oatmeal contains a good deal of phytic acid. Brown flour and National flour contain phytic acid too, but some of this is destroyed during bread-making, owing to the action of phytase, an enzyme which destroys phytic acid, and which is present in

TABLE 5. *Summary of the Main Points about the Vitamins*

	Chief results of deficiency	*Principal sources*	*Effect of cooking*
Vitamin A	Night-blindness, infections of mucous membranes, xerophthalmia	As vitamin A: halibut-liver oil, cod-liver oil, liver, eggs, butter, vitaminized margarine, milk, cheese, and fatty fish. As carotene: orange- and yellow-coloured vegetables and fruits, and green vegetables	Not destroyed
Vitamin B_1 (aneurin)	Beri-beri	Yeast, wheat-germ, oatmeal, brown bread, National bread, pork, bacon, ham, liver, kidney, and other meat, peas, beans, and eggs	Some is destroyed by heat, especially if the reaction is alkaline. Some diffuses out when foods are boiled in water
Riboflavin	(See p. 53)	Yeast, liver, eggs, milk, cheese, meat, fish, peas, beans, brown bread, and National bread	A small amount is destroyed by heat and some diffuses out when foods are cooked in water
Nicotinic acid	Pellagra	Yeast, meat, fish, brown bread, National bread, and potatoes	Hardly destroyed at all by heat. Some diffuses out when foods are cooked in water
Vitamin C (ascorbic acid)	Scurvy	Fruits, especially blackcurrants, oranges, lemons, grapefruits, rosehips, strawberries, and gooseberries; and vegetables, especially kale, Brussels sprouts, cabbage, cauliflower, parsley, new potatoes, swedes, and tomatoes	May be destroyed by oxidase; also by heat (unless protected by acid), especially in the presence of oxygen. Some diffuses out when foods are cooked in water
Vitamin D	Rickets	Halibut-liver oil, cod-liver oil, fatty fish, eggs, summer butter, vitaminized margarine. (For the effect of sunlight, see pp. 59–61)	Not destroyed

wheat. Unfortunately, oatmeal contains no phytase, and therefore has a more strongly anti-calcifying action than either brown flour or National flour. White flour has no anti-calcifying action, since the phytic acid of wheat occurs mainly in the bran, and white flour contains no bran. During the war, when it was necessary to use National flour instead of white flour to save shipping space, the anti-calcifying power of the phytic acid was neutralized by adding to National flour extra calcium, usually in the form of pure calcium carbonate.

Old and new views on rickets. One of the many interesting points about the experimental work on rickets is that it links up previously conflicting views. The effect of housing conditions on rickets is now attributed to the lack of sunshine in slums; the idea that rickets was due to lack of fat is explained by the fact that a diet deficient in fat would almost certainly be deficient in fat-soluble vitamin D; and the suggestion that excess of cereals was responsible is now known to be due to the anti-calcifying action of phytic acid.

Vitamin E

Vitamin E is concerned with fertility. It has been known for some time that white rats become sterile and unable to reproduce if this vitamin is absent from their diet. As soon as they have a good supply of vitamin E they become normal again. It has also been claimed that vitamin E deficiency is responsible for a certain type of sterility in human beings, but the evidence is not conclusive.

Vitamin E is fat-soluble. It is found especially in green leaves, such as lettuce and watercress, in the 'germ' of cereals, and to a less extent in milk. It has the chemical formula $C_{29}H_{50}O_2$ and is a member of the alcohol series.

Vitamin K

Vitamin K is a fat-soluble substance that is required in the body for the formation of a proper blood clot to stop bleeding. The 'K' stands for 'Koagulation'. Most people obtain as much as they require from their ordinary diets (see also p. 79).

Vitamin Deficiency in General

The people who are in most danger of suffering from vitamin deficiency are those who live on restricted diets, as may be the case with soldiers, sailors, airmen, explorers, and even civilians under war-time conditions. Infants also come into this category, restricted as they are to a milk diet. One great practical difficulty about deficiency diseases is that they are often multiple, since diets that lack one vitamin tend to lack two or three. Another important point is that deficiencies of vitamins are probably responsible for a good deal of ill health, even if they are not serious enough to produce such acute conditions as scurvy or pellagra. We must therefore make sure that our diet is not even partially deficient in any of these essential substances.

Some of the points about vitamin A, vitamin B_1, riboflavin, nicotinic acid, vitamin C, and vitamin D are summarized in Table 5, p. 64.

CHAPTER V

SCIENTIFIC STANDARDS FOR DIETS

Read not to contradict and confute, nor yet to believe and take for granted, . . . but to weigh and consider.

BACON.

UNFORTUNATELY we are not yet in a position to set up final dietetic standards. It is not an easy matter to find out how much of each nutrient we need, and nowadays we modestly talk about 'recommended allowances' instead of bodily requirements. Even these suggested allowances are by no means final. Many of them have been altered already more than once, and probably further research will show that still more alterations are necessary.

One of the difficulties about standard allowances is that the required amount of a particular nutrient may depend on the composition of the diet as a whole. For instance, it is necessary to have a larger daily allowance of vitamin B_1, riboflavin, and nicotinic acid if the diet contains a specially large amount of carbohydrate; and more calcium is needed if the diet is not well supplied with vitamin D, or if there is a considerable amount of phytic acid in the food. Another difficulty is that people's requirements vary a great deal, even if they are of the same age, sex, and occupation. Standards obviously have to be average values, but the needs of an individual may be above or below the average. Thus, some people utilize their food more efficiently than others. This may be due to individual variations in hormone activity. Then again, people are able to perform special types of physical work with less expenditure of energy if they are in the habit of using the particular muscles involved. This is the secret of training. An athlete in training is able to carry out his special activity with the minimum expenditure of energy, and he therefore uses up far fewer calories than when he is not in training. From this it is clear that recommendations for daily allowances should be used with great caution. In spite of their limitations, however, dietetic standards are of considerable value for nutrition workers, and we shall now deal with suggested daily allowances of calories, and of various nutrients.

Daily Allowances of Calories

Calories for men. In 1881 the German investigator Voit estimated that the daily allowance for an average workman should be 3,055 calories; and the round figure of 3,000 calories has been the classical standard ever since. We find the very same figure of 3,000 calories a day for a moderately active man in *Recommended Dietary Allowances*, the 'standard' now in general use. This 'standard' was put forward in January 1943 by the National Research Council of the U.S.A., and was adopted in June 1943 by the United Nations Conference on Food and Agriculture at Hot Springs, Virginia, 'as a tentative goal toward which to aim in planning practical dietaries'. It is given in Table 9, p. 78, as revised by the National Research Council of the U.S.A. in 1945. According to these recommendations, very active men are allowed 4,500 calories a day, moderately active men 3,000 calories, and sedentary men 2,500 calories.

Although it is convenient to fix the average daily allowance for a moderately active man at 3,000 calories, it must be remembered that there is great variation among individuals. In an investigation of individual diets carried out by Miss Widdowson, one man had a daily intake of only 1,772 calories, whereas another man of the same age and a fairly similar occupation had a daily intake of 4,955 calories. The average daily intake for the whole group of 63 men of various occupations was 3,067, which agrees very closely with the classical allowance of 3,000 calories, though the classical figure was for men of moderate activity, whereas the 63 men in the recent investigation were chiefly of sedentary occupation.

Calories for women. On the average, women need rather less calorie-producing food than men, because they usually weigh less (their average weight of 9 stone is only five-sixths that of the average man), and are less active and muscular, and also because they produce slightly less heat per unit of surface area. Most physiologists consider that, on the average, women need only 83 per cent. (five-sixths) as many calories as men, and some workers think that even 83 per cent. is rather too high a figure. Professor McCance and Miss Widdowson found that the daily intake of 63 women was only 70 per cent. of that of the same number of men in similar circumstances. With the women, as with the men, there was a great deal of individual variation. The average for the whole group of 63 women, mostly middle-class sedentary workers or housewives, was 2,187 calories a day, and the values ranged from 1,453 to 3,110. This average figure, 2,187, is practically identical with the value given in *Recommended Dietary Allowances* (2,100 for sedentary women, see Table 9, p. 78); according to this 'standard', moderately active women are allowed 2,500 calories a day, and very active women 3,000. There are increased allowances for women in the later stages of pregnancy and for nursing mothers.

Calories for elderly people. From about the age of 60, fewer calories are needed because the bodily activities diminish; and after the age of 70, about 1,800 calories a day are usually sufficient.

Calories for children. Children need more calories per pound of body-weight than adults, because they are more active and have a higher basal metabolism per unit of surface area. Calorie allowances for children up to 12 years old and for boys and girls of 13–20 are given in Table 9, p. 78. These are, of course, average values. As might be expected, the needs of children are even more variable than those of grown-up people. Some children are far more active than others. Some are taller, and others heavier for a given age. Also, as with adults, there is an individual factor, which varies even when other factors are more or less the same. Thus, in a recent investigation of children's diets, Professor

McCance and Miss Widdowson found that the daily calorie intake of 34 girls, all 13 years old, varied between 1,706 and 3,736; moreover, in every age group for both boys and girls there was one child who ate twice as much as some other child of the same age and sex; there was actually a boy of 2 who ate more than a boy of 17.

Calorie values and the use of the terms 'A.P.' and 'E.P.' When we say that a diet should provide 3,000 calories a day, we mean that this should be the calorie value of the food that is eaten. The waste, such as bones and fruit skins, and the nutritive material lost during cooking are not included. The 3,000 calories is a net value. In order to obtain enough food to provide this net calorie value, a certain amount of extra food has to be bought, to allow for waste in food preparation and cooking. The amount of waste naturally varies a great deal with different foods. Some foods, such as bread, butter, and sugar, have no waste at all, but fruit and vegetables often have a considerable amount of waste, and so do meat and fish, unless they are boneless. Food tables often give average values for the amount of waste, but in actual practice there may be far more or far less waste than the value given in the table. There is no doubt that it is much more accurate to work out diets from the weight of the edible part of the food as eaten, rather than from the weight of the food as it is bought minus an arbitrary amount to represent waste. In this book calorie values and other values refer to the edible portion only. The terms 'A.P.' and 'E.P.' are sometimes used to mean 'as purchased' and 'edible portion' respectively.

Daily Allowances of Protein

When we have settled the calorie allowance of a diet, the next step is to fix the proportion of protein, carbohydrate, and fat. First of all let us take protein, because it is necessary for body-building and cannot be replaced for this purpose by either fat or carbohydrate. Although we need very different amounts of calorie-producing food according to the amount of exercise we take, we need about the same amount of protein for body-building, however we spend our time. Since protein foods impose a strain on the kidneys, it may be advisable for us not to eat them in great excess, although it must be admitted that the Eskimos eat large amounts of protein without showing any great tendency to kidney disease.

The question of protein requirement has been the subject of a good deal of controversy in the scientific world. In 1881 Voit advocated a daily allowance of 118 grammes of protein for an average working man. Then, in 1892, Atwater put the allowance up to 125 grammes, and this remained the classical standard for many years. But gradually the pendulum began to swing back the other way. In 1904 Chittenden of Yale showed that groups of soldiers, athletes, and professional men could maintain their efficiency for several months on diets containing less than 60 grammes of protein a day; and in 1906 Hindhede, a Danish physician who lived mainly on potatoes, found that he could remain in good health for long periods when his protein intake was cut down to the astonishingly low figure of 32 grammes a day. Most physiologists, however, considered that it was unwise to fix the daily ration of protein at such a low level, and 125 grammes a day remained the accepted standard.

Coming to more recent times, we find a general trend downwards. In 1931 the Ministry of Health recommended a daily allowance of 100 grammes of protein for an average man, but reduced this to 80–100 grammes three years later, in a joint report with the British Medical Association. By 1935 the Technical Commission of the League of Nations brought the protein down still farther—to 70 grammes for men and 57 for women. Similar amounts are given in *Recommended Dietary Allowances*, namely, 70 grammes for men and 60 for women. These values are considerably lower than the average intake of the 63 men and women whose diets were investigated in 1936 by Professor McCance and Miss

Widdowson. They found that the average was 98 grammes for men and 67 for women, the ranges being 53–167 grammes for men and 23–90 grammes for women. As might be expected, extra allowances are needed by expectant and nursing mothers (see Table 9, p. 78).

Since children need protein for growth as well as for the daily renewal of tissues, they need more protein in relation to body-weight than adults do. Protein allowances for children of various ages are given in Table 9, p. 78.

Protein in terms of food. The following portions of food each contain about 20 grammes of protein:

1 pint of milk
3 oz. of cheese
3 oz. of cooked lean meat
4 oz. of cooked fish
3 eggs
8 oz. of bread
10 oz. of cooked haricot beans.

It would take about 3 such portions to provide the average daily allowance for a woman, and about 3½ portions for that of a man.

Since animal proteins are usually of higher quality than plant proteins, it used to be considered advisable to have a third or half of the daily ration of protein from animal sources. Nowadays this view is not so commonly held, since it has been found that proteins from different sources are often able to supplement one another. Even so, animal products are still the best protein foods because they contain so much more protein than plant products do.

Daily Allowances of Carbohydrate and Fat

Since every gramme of protein yields 4·1 calories, the daily ration of 70 grammes of protein will yield 287 calories; there remain 2,713 calories out of the average man's daily allowance of 3,000 calories to be supplied as carbohydrate or fat. The proportion of carbohydrate to fat is largely an individual matter, because people vary in their tolerance to fat. People who do heavy work eat a great deal of fat, but the proportion of fat to carbohydrate in their diets may be no greater than that in the diets of people who do light work indoors. For instance, a group of lumbermen in Maine, whose ordinary daily diet yielded the extraordinarily high average value of 8,083 calories a day, obtained 49 per cent. of their calories from carbohydrate and only 43 per cent. from fat. These percentages are not very different from those obtained by Professor McCance and Miss Widdowson in their investigation of individual diets; they found that the fat intake averaged at 39·1 per cent. of the total calories for the men, and at 42·7 per cent. for the women. The values for the whole group of 63 men and 63 women ranged from 29·0 to 50·8 per cent. for the men and from 32·6 to 54·9 per cent. for the women. These fat intakes are much higher than those obtained in most of the earlier dietary investigations carried out in this country, possibly because the men and women were better off financially than the subjects of former studies. Fat is expensive, and therefore poor people tend to eat less than those who have plenty of money to spend on food (see Sir John Orr's *Food, Health, and Income*). In a dietary study of six unemployed men and their wives, Professor McCance and Miss Widdowson found that the percentage of total calories from fat was, on the average, only 31·4 for the men and 34·8 for the women.

As might be expected, poor people obtain a high proportion of their total calories from carbohydrates, because carbohydrate foods are cheap. The six unemployed men mentioned above obtained, on the average, 56·8 per cent. of their total calories from carbohydrate, and their wives obtained 52·5 per cent. Similar values for the groups of middle-class people ranged from 33·5 to 59·8 (with an average of 46·7) per cent. of the total calories from carbohydrate for the men, and from 16·7 to 56·5 (with an average of 43·6) per cent. for the women.

Daily Allowances of Mineral Elements

The amounts of certain mineral elements in the diet of a healthy man are given in Table 6; these cannot be taken as standards but are useful for purposes of comparison.

TABLE 6. *The Average Daily Intake of Eight Mineral Elements*

Chlorine	7·1 grammes	Calcium	0·7 grammes
Sodium	4·6 ,,	Magnesium	0·34 ,,
Potassium	3·4 ,,	Iron	14 milligrammes
Phosphorus	1·4 ,,	Copper	3 ,,

[From *The Nutritive Value of Fruits, Vegetables, and Nuts*, by R. A. McCance, E. M. Widdowson, and L. R. B. Shackleton (H.M. Stationery Office), 1936.]

The amounts of magnesium, copper, manganese, chlorine, and phosphorus in ordinary diets are probably sufficient to satisfy our needs, and the amount of potassium is too great rather than too little. Sodium may not occur in large enough amounts in diets, but this deficiency can easily be made good by additions of common salt (sodium chloride). Deficiencies of calcium, iron, and iodine are not so easy to deal with, however, and these elements will now be considered very briefly.

Calcium. Recommended Dietary Allowances gives a daily allowance of 0·8 gramme of calcium for adults, 1 gramme for children up to 9 years old, and 1·2 to 1·4 for older children (see Table 9, p. 78). Women need an extra supply during pregnancy and lactation, the suggested amounts being 1·5 and 2·0 grammes respectively. One gramme of calcium can be obtained from a pint and a half of milk or from about 4 ounces of cheese. Portions of foods containing half a gramme of calcium are given in Table 7.

Iron. The recommended allowances of iron are 12 mg. for adults, 6–12 mg. for children under 12 years old, and 15 mg. for girls and boys between the ages of 13 and 20. During pregnancy and lactation the suggested allowance is 15 mg. (see Table 9, p. 78). There are 12 mg. of iron in two or three ounces of cooked liver or kidney, or half a pound of roast beef. Table 7 gives portions of food containing 6 mg. of iron.

TABLE 7. *Portions of Food containing Definite Amounts of Calcium and Iron*

CALCIUM	IRON
There is about half a gramme of calcium in:	*There are about* 6 *mg. of iron in:*
¾ pint of milk	1 oz. of cooked liver
1½ oz. of dried 'household' milk	1½ oz. of cooked kidney
2 oz. of cheese	2 oz. of corned beef
2 oz. of fried whitebait	2½ oz. of black treacle
2½ oz. of cooked sprats	4 oz. of cooked beef
4½ oz. of tinned sardines	10 oz. of brown bread

Iodine. We need far smaller amounts of iodine than of the elements we have just been considering (see 'Further Recommendations', p. 79). The best way to secure an adequate supply is to use iodized salt instead of ordinary salt.

Daily Allowances of Vitamins

Suggested daily allowances are given in Table 9, p. 78. It will be noticed that the amounts of vitamin B_1, riboflavin, and nicotinic acid fluctuate according to the calorie value of the diet. Definite amounts of vitamins are translated into terms of food in Table 8, p. 76.

The Analysis and Criticism of Individual Diets

If we want to know whether a diet is good or not, we must find out if the calorie value is suitable, and if there is an adequate amount of protein, calcium, iron, vitamin A, vitamin B_1, riboflavin, nicotinic acid, vitamin C, and vitamin D. The best way to do this is to weigh out all the food that is eaten for a week and analyse the results. An example of such an analysis is given on p. 77.

TABLE 8. *Portions of Food containing Definite Amounts of Vitamins*

VITAMIN A	VITAMIN B$_1$
There are about 1,000 *Int. units of vitamin A in:*	*There is about half a milligramme of vitamin* B$_1$ *in:*
1 drop of halibut-liver oil	1 oz. of edible food yeast
¼ teaspoonful of cod-liver oil	1¼ oz. of cod roe
¼ oz. of cooked liver	2½ oz. of pork
½ oz. of cooked carrots[1]	3 oz. of bacon or ham
1 oz. of Empire butter	3 oz. of soya bean flour
1½ oz. of cooked kale[1]	4½ oz. of liver
3 oz. of cheese	10 oz. of brown bread
RIBOFLAVIN	**NICOTINIC ACID**
There is about half a milligramme of riboflavin in:	*There are about five milligrammes of nicotinic acid in:*
½ oz. of edible food yeast	1 oz. of edible food yeast
1 oz. of cooked liver	1 oz. of cooked liver
1 oz. of dried household milk	2 oz. of cooked veal or poultry
1½ oz. of dried egg powder	3 oz. of tinned salmon
¾ pint of milk	3½ oz. of tinned sardines
4 oz. of cheese	4 oz. of cooked beef or mutton
VITAMIN C	**VITAMIN D**
There are about twenty-five milligrammes of vitamin C in:	*There are about* 400 *Int. units of vitamin D in:*
½ oz. of black-currants	2 drops of halibut-liver oil
½ oz. of nasturtium leaves	½ teaspoonful of cod-liver oil
¾ oz. of parsley	1½ oz. of tinned sardines
Half an orange or lemon	2 oz. of cooked herrings
1¼ oz. of raw cabbage	2 oz. of cooked mackerel
1½ oz. of watercress	2 oz. of cooked kippers
1½ oz. of strawberries	2 oz. of cooked bloaters
2½ oz. of gooseberries	2½ oz. of tinned salmon
3 oz. of raspberries	6 oz. of dried egg powder
3 oz. of raw swede juice	7 oz. of vitaminized margarine
3 oz. of carefully cooked cabbage	1½ lbs. of Empire butter
3½ oz. of tomatoes	
6 oz. of boiled new potatoes	

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[1] Present in the form of carotene. The Int. units were, therefore, divided by three before these quantities were worked out.

Analysis of a child's diet. Here is a record of the investigation of the diet of a little girl aged 9. All her food for a week has been weighed on a special balance. The ordinary kitchen scales are not accurate enough for this purpose, because we want to know the weight of each food to the nearest quarter of an ounce. Each kind of food (bread, butter, fish, and so on) was weighed separately.

The child's meals for one day were as follows:

Breakfast	A boiled egg.
	Bread with butter and black-currant jam.
	Cocoa to drink.
Dinner	Roast mutton with potatoes, cabbage, and carrots.
	Semolina pudding.
	Water to drink.
	An orange.
	1 teaspoonful of cod-liver oil.
Tea	Bread with margarine and dates.
	Biscuits.
	Milk to drink.
Supper	An apple.

The weight of each food (edible portion) is given in Table 10, p. 80. The cocoa-powder, milk, and sugar were weighed separately before the cocoa was made. Other foods were weighed immediately before being eaten. Any food left uneaten on the plate was subtracted from the original amount.

The figures for protein, carbohydrate, &c., in Table 10 have been taken from the tables on pages 158 to 170. The carotene values have been divided by 3 before being entered up. To allow for cooking losses the vitamin C values for cooked vegetables were divided by 2, the vitamin B_1 in the roast meat was divided by 2 and that in cooked vegetables by 3 (see p. 157).

When we have filled in the values for all the nutrients, we can add up the totals for the day. In actual practice the weighing of the food should be continued for seven days, and the totals for the week divided by 7 to give an average day's diet. But it will save a good deal of repetition if we

TABLE 9. *Recommended Dietary Allowances*[1]

REVISED 1945

Food and Nutrition Board, National Research Council, Washington, D.C.

	Calories	*Protein*	*Calcium*	*Iron*	*Vitamin A*[2]	*Vitamin* B_1[3]	*Riboflavin*[3]	*Nicotinic acid*[3]	*Vitamin C*	*Vitamin D*
		gm.	gm.	mg.	I.U.	mg.	mg.	mg.	mg.	I.U.
Man (154 lb.)										
Sedentary . .	2,500	70	0·8	12[4]	5,000	1·2	1·6	12	75	[5]
Moderately active	3,000	70	0·8	12[4]	5,000	1·5	2·0	15	75	[5]
Very active . .	4,500	70	0·8	12[4]	5,000	2·0	2·6	20	75	[5]
Woman (123 lb.)										
Sedentary . .	2,100	60	0·8	12	5,000	1·1	1·5	11	70	[5]
Moderately active	2,500	60	0·8	12	5,000	1·2	1·6	12	70	[5]
Very active . .	3,000	60	0·8	12	5,000	1·5	2·0	15	70	[5]
Pregnancy (latter half)	2,500[6]	85	1·5	15	6,000	1·8	2·5	18	100	400–800
Lactation . .	3,000	100	2·0	15	8,000	2·0	3·0	20	150	400–800
Children up to 12 yrs.[7]										
Under 1 yr.[8] .	100 per 2·2 lb.	3·5 per 2·2 lb.	1·0	6	1,500	0·4	0·6	4	30	400–800
1–3 yrs. (29 lb.) .	1,200	40	1·0	7	2,000	0·6	0·9	6	35	400
4–6 yrs. (42 lb.) .	1,600	50	1·0	8	2,500	0·8	1·2	8	50	400
7–9 yrs. (55 lb.) .	2,000	60	1·0	10	3,500	1·0	1·5	10	60	400
10–12 yrs. (75 lb.)	2,500	70	1·2	12	4,500	1·2	1·8	12	75	400
Children over 12 yrs.[7]										
Girls, 13–15 yrs. (108 lb.)	2,600	80	1·3	15	5,000	1·3	2·0	13	80	400
16–20 yrs. (119 lb.)	2,400	75	1·0	15	5,000	1·2	1·8	12	80	400
Boys, 13–15 yrs. (103 lb.)	3,200	85	1·4	15	5,000	1·5	2·0	15	90	400
16–20 yrs. (141 lb.)	3,800	100	1·4	15	6,000	1·8	2·5	18	100	400

I.U. = International units

[1] Tentative goal toward which to aim in planning practical dietaries; can be met by a good diet with a variety of natural foods. Such a diet will also provide other minerals and vitamins, the requirements for which are less well known.

[2] The allowance depends on the relative amounts of vitamin A and carotene. The allowances of the table are based on the premise that approximately two-thirds of the vitamin A value of the average diet in this country is contributed by carotene and that carotene has half or less than half the value of vitamin A.

[3] For adults (except pregnant and lactating women) receiving diets supplying 2,000 calories or less, such as reducing diets, the allowances of vitamin B_1, riboflavin, and nicotinic acid may be 1 mg., 1·5 mg. and 10 mg. respectively. The fact that figures are given for different calorie levels for vitamin B_1, riboflavin, and nicotinic acid, does not imply that we can estimate the requirement of these factors within 500 calories, but they are added merely for simplicity of calculation. Other members of the B complex also are required, though no values can be given. Foods supplying adequate vitamin B_1, riboflavin, and nicotinic acid will tend to supply sufficient of the remaining B vitamins.

[4] There is evidence that the male adult needs little or no iron. The allowance will be provided if the diet is satisfactory in other respects.

[5] For persons who have no opportunity for exposure to clear sunshine and for elderly persons, the ingestion of small amounts of vitamin D may be desirable. Other adults probably have little need for vitamin D.

[6] During the latter part of pregnancy the allowance should increase approximately 20 per cent. over the preceding level. The value of 2,500 calories represents the allowance for pregnant, sedentary women.

[7] Allowances for children are based on the needs for the middle year in each group (as 2, 5, 8, &c.) and are for moderate activity and for average weight at the middle year of the age group.

[8] Needs of infants increase from month to month with size and activity. The amounts given are for approximately 6 to 8 months. The dietary requirements for some of the nutrients such as protein and calcium are less if derived largely from human milk.

FURTHER RECOMMENDATIONS

Fat. There is available little information concerning the human requirement for fat. Fat allowances must be based at present more on food habits than on physiological requirements. While a requirement for certain unsaturated fatty acids (the linoleic and arachidonic acids of natural fats) has been amply demonstrated with experimental animals, the human need for these fatty acids is not known. In spite of the paucity of information on this subject there are several factors which make it desirable that fat be included in the diet to the extent of at least 20 to 25 per cent. of the total calories and that the fat intake include 'essential' unsaturated fatty acids to the extent of at least 1 per cent. of the total calories. At higher levels of caloric expenditure, e.g. for a very active person consuming 4,500 calories and for children and adolescent persons, it is desirable that 30 to 35 per cent. of the total calories be derived from fat. Since foodstuffs such as meat, milk, cheese, and nuts may be expected to contribute 'invisible' fat to the extent of from one-half to two-thirds of the total amounts of fat implied by the above proportions of the total calories, it is satisfactory to use separated or 'visible' fats such as butter, margarine, lard, and shortenings only to the extent of one-third to one-half of the amounts indicated.

Copper. The requirement for copper for adults is about 1 to 2 mg. daily. Infants and children require approximately 0·05 mg. for each kilogramme of body weight. The requirement for copper is approximately one-tenth that for iron. A good diet normally will supply sufficient copper.

Iodine. The requirement for iodine is small, probably about 0·002 to 0·004 mg. daily for each kilogramme of body weight, or a total of 0·15 to 0·30 mg. daily for the adult. This need is met by the regular use of iodized salt; its use is especially important in *adolescence* and *pregnancy*.

Phosphorus. Available evidence indicates that the phosphorus allowances should be at least equal to those for calcium in the diets of children and of women during the latter part of pregnancy and during lactation. In the case of other adults the phosphorus allowances should be approximately 1·5 times those for calcium. In general it is safe to assume that if the calcium and protein needs are met through common foods, the phosphorus requirement also will be covered, because the common foods richest in calcium and protein are also the best sources of phosphorus.

Vitamin K. The requirement for vitamin K usually is satisfied by any good diet. Special consideration needs to be given to newborn infants. Physicians commonly give vitamin K either to the mother before delivery or to the infant immediately after birth.

Salt. The needs for salt and for water are closely interrelated. A liberal allowance of sodium chloride for the adult is 5 grammes daily, except for some persons who sweat profusely. The average normal intake of salt is 10 to 15 grammes daily, an amount which meets the salt requirements for a water intake up to 4 litres daily. When sweating is excessive, one additional gramme of salt should be consumed for each litre of water in excess of 4 litres daily. With heavy work or in hot climates 20 to 30 grammes daily may be consumed with meals and in drinking water. Even then, most persons do not need more salt than usually occurs in prepared foods. It has been shown that after acclimatization persons produce sweat that contains only about 0·5 gramme to the litre in contrast with a content of 2 to 3 gramme for sweat of the unacclimatized person. Consequently after acclimatization, need for increase of salt beyond that of ordinary food disappears.

Water. A suitable allowance of water for adults is 2·5 litres daily in most instances. An ordinary standard for diverse persons is 1 millilitre for each calorie of food. Most of this quantity is contained in prepared foods. At work or in hot weather, requirements may reach 5 to 13 litres daily. Water should be allowed *ad libitum*, since sensations of thirst usually serve as adequate guides to intake except for infants and sick persons.

[From *Recommended Dietary Allowances, Revised 1945*. National Research Council Reprint and Circular Series, Washington, D.C., U.S.A. No. 122. August, 1945.]

TABLE 10. *The Analysis of an Individual Diet*

	Protein	*Fat*	*Carbo-hydrate*	*Calories*	*Calcium*	*Iron*	*Vitamin A*	*Vitamin B₁*	*Ribo-flavin*	*Nicotinic acid*	*Vitamin C*	*Vitamin D*
Breakfast:	gm.	gm.	gm.		mg.	mg.	I.U.	µg.	µg.	mg.	mg.	I.U.
2 oz. bread (85%), fortified	4·8	0·6	31·6	144	34·6	1·04	0	86	—	—	0	0
1 boiled egg (2 oz.)	6·8	7·0	0	92	31·8	1·44	566	86	226	0	0	34
¼ oz. butter	0	6·0	0	56	1·0	0·01	284	0	—	0	0	4
½ oz. black-currant jam	0·1	0	9·8	37	3·4	0·21	1	0	—	0	3	0
10 oz. milk (winter)	9·0	11·0	14·0	190	341·0	0·20	200	130	430	0	0	0
¼ oz. cocoa powder	1·4	1·6	2·5	32	3·8	1·01	4	8	—	0·2	0	0
¼ oz. sugar	0	0	7·4	28	0·1	0	0	0	0	0	0	0
Dinner:												
2 oz. roast mutton	14·2	11·6	0	166	2·4	2·44	28	45	142	3·4	0	—
3 oz. boiled potatoes (Dec.)	1·2	0	16·8	69	3·6	0·42	0	34	42	0·9	6	0
2 oz. boiled cabbage	0·4	0	0·8	6	33·2	0·26	170	14	28	0·2	20	0
3 oz. boiled carrots (old)	0·6	0	3·6	15	30·4	0·33	5,672	17	42	0·4	4	0
2 oz. semolina pudding	2·4	2·2	11·4	74	68·0	0·12	—	—	—	—	0	0
1 orange (3 oz.)	0·6	0	7·2	30	35·1	0·27	85	63	27	0	48	0
1 teaspoonful cod-liver oil (⅛ oz.)	0	3·5	0	32	—	—	3,550	—	—	—	0	710
Tea:												
2 oz. bread (85%), fortified	4·8	0·6	31·6	144	34·6	1·04	0	86	—	—	0	0
¾ oz. vitaminized margarine	0	18·0	0	168	0·8	0·06	426	0	—	0	0	42
1 oz. dates	0·6	0	18·1	70	19·2	0·46	9	0	—	—	0	0
2 oz. sweet biscuits	3·2	17·4	37·8	316	15·4	0·48	0	36	—	—	0	0
10 oz. milk (winter)	9·0	11·0	14·0	190	341·0	0·20	200	130	430	0	0	0
Supper:												
1 apple (3 oz.)	0·3	0	10·5	39	3·0	0·24	11	39	27	0	3	0
Total	59·4	90·5	217·1	1,898	1,002·4	10·23	11,206	774	1,394	5·1	84	790
Recommended Dietary Allowance for child 7–9 years	60	—	—	2,000	1,000	10	3,500	1,000	1,500	10	60	400

omit that stage here and proceed at once to a criticism of the day's diet given above.

Criticism of the diet in Table 10. The values for a child of 7–9 years old from *Recommended Dietary Allowances* are given at the bottom of Table 10 for purposes of comparison. It can be seen that the diet we are considering contains rather fewer calories but about the same amount of protein, calcium, iron, and vitamin C as the recommended allowances, and there is a considerable surplus of vitamins A and D. The totals for vitamin B_1, riboflavin, and nicotinic acid, on the other hand, are lower than the suggested allowances; but it must be remembered that several of the foods in Table 10 contain these vitamins in unknown amounts; unfortunately our food tables still have many gaps, especially where the vitamins are concerned.

Dietary Surveys

In the past, dietary surveys have often been calculated on the basis of the so-called man-value of the group. An average man was said to have a man-value or coefficient of 1, and children were given man-values according to their ages. The coefficient (man-value) of a woman was usually given as 0·83, but the Health Committee of the League of Nations in their Report of 1936 gave it as 1; they also gave a coefficient of 1 for pregnant women, and of 1·25 for nursing mothers. Here is a list of their coefficients for children:

Age in years	*Coefficient*
1–2	0·35
2–3	0·42
3–5	0·5
5–7	0·6
7–9	0·7
9–11	0·8
11–12	0·9
12–15	1·0
15 and upwards	1·0

The method of using man-values or coefficients is as follows. If we want to find the average daily calorie allowance for a family consisting of a man and his wife, both engaged in moderately active work, and three children aged 10, 8, and 6 respectively, we first find the man-value of the group, and then multiply it by the calorie allowance for a moderately active man. If we use the League of Nations Health Committee coefficients, we find that:

$$\text{The man-value of the family} = 1+1+0{\cdot}8+0{\cdot}7+0{\cdot}6$$
$$= 4{\cdot}1.$$

If we then take 3,000 calories a day as the allowance for a moderately active man, we find that:

$$\text{The calorie allowance for the family} = 4{\cdot}1 \times 3{,}000$$
$$= 12{,}300 \text{ calories a day.}$$

The great objection to the use of man-values or coefficients is that even if they are correct for calories they cannot be correct for all other nutrients, since children need a relatively higher proportion of protein, calcium, and most vitamins than adults do. Moreover, man-values take no account of individual members of the group. For instance, with the family mentioned above, the calorie value of the total food consumed may be equal to the recommended allowance for the whole group, and yet it is impossible to say whether each individual is getting a fair share. If one member of the family overeats, it is not much comfort for the others to know that the calorie value of the total food is adequate. In such a case, the investigation of individual diets gives far more satisfactory results.

The individual method, however, becomes impossible if very large numbers of people are included in the survey. In such a case, it is necessary to find out the quantities of raw food that make up the diet, and make allowances for losses in storage, food preparation, and cooking. The amounts of the separate nutrients can then be calculated. In the rare event of the people under investigation being all of the same age, sex, and degree of activity, the total nutrients could be divided by the number of people to give an average value. Otherwise, the group of people must be divided into subclasses according to age, sex, and occupation, so that the theoretical needs of the whole group can be calculated from *Recommended Dietary Allowances*. These theoretical figures can then be compared with the actual amounts of nutrients consumed by the whole group. When whole populations are involved, it is impossible to estimate the degree of activity accurately, and it is therefore customary to assume that both men and women (other than expectant and nursing mothers) are, on the average, 'moderately active'.

CHAPTER VI

THE CHOICE OF FOOD

> Some people have a foolish way of not minding or pretending not to mind what they eat. For my part, I mind my belly very studiously, and I look upon it that he who does not mind his belly will hardly mind anything else.
>
> DR. JOHNSON.

AFTER our rapid survey of the general principles of nutrition, we are now in a position to deal directly with a subject about which a good deal has already been said incidentally, or by way of illustration. We can consider the good and bad points of some ordinary foods, and the effect of cooking on the nutritive value. We will start with bread and then take other cereal foods, sugar and sugary foods, fruit, vegetables, nuts, milk, and milk products, eggs, fish, meat, dehydrated foods, proprietary foods, and beverages. Food handling will also be considered very briefly.

Bread

Bread only contains about 8 per cent. of protein, but in this country it is a most important source of protein, because we eat such large amounts of bread. Even in 1934–8, in the days of peace and plenty, we obtained over a third of our total protein from cereal products, and most of this was from bread and flour. Bread also provides us with starch, and acts as a cheap source of calories. Brown bread and National bread contain roughage and are good sources of iron, vitamin B_1, and nicotinic acid, but white bread contains less of these substances.

In order to appreciate these differences in nutritive value between the various types of bread, we must consider for a moment the structure of a grain of wheat (see Fig. 6). There are three main parts: the husk or bran outside, the starchy endosperm inside, and the small germ embedded in one corner of the endosperm. Each of these parts is subdivided. The bran consists of the hard brown pericarp and an inner layer of special protein-laden cells called the aleurone layer. The endosperm is divided into the narrow outer layer and the much larger inner portion. The germ contains the embryo, together with the scutellum, which separates the embryo from the endosperm.

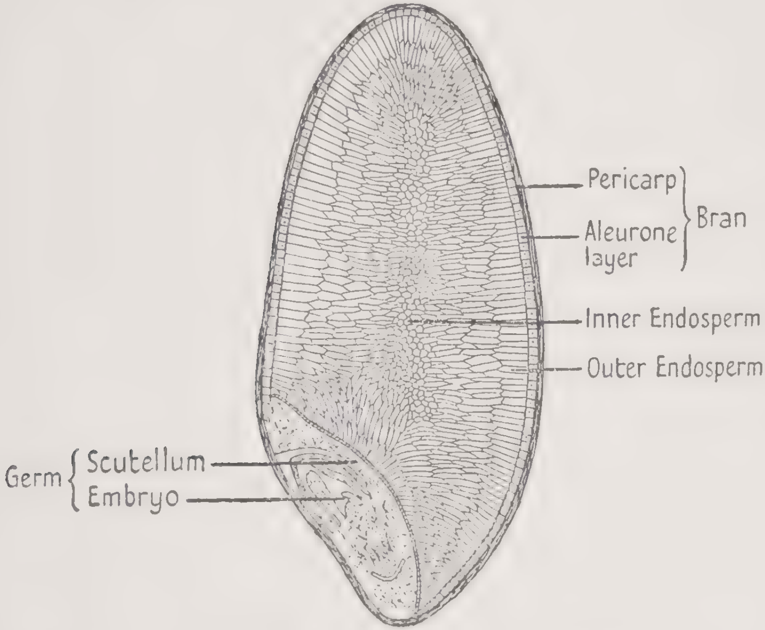


FIG. 6. Diagram of a longitudinal section of a grain of wheat.

[From *Report to the Local Government Board on the Nutritive Value of Bread made from Different Varieties of Wheat Flour*, by J. M. Hamill, (H.M. Stationery Office), 1911.]

These parts of the wheat grain differ from one another a great deal both in chemical composition and in nutritive value. The inner portion of the endosperm, which makes up no less than 83 per cent. of the weight of the whole wheat grain (see Table 11, p. 86), contains the most starch but is of the least value in nutrition because it contains a lower percentage of protein, iron, vitamin B_1, riboflavin, and nicotinic

TABLE 11. *The Component Parts of the Wheat Grain expressed as Percentages of the Whole*

		Percentage (by weight) of wheat grain
Bran	Lignified outer layers	4·0
	Aleurone layer	8·3
Endosperm	Outer layers	2·0
	Inner portion	83·0
Germ	Scutellum	1·5
	Embryo	1·2
	Total	100·0

[From 'Bread' by R. A. McCance, *Lancet*, 1946 (i), p. 77.]

acid than the rest of the grain. Moreover, the quality of the protein is inferior to that of the mixed proteins of whole wheat. The outer layers of the endosperm are considerably better than the inner portion, since they contain a higher percentage of protein, iron, and vitamins, and are particularly rich in nicotinic acid (see Table 12). The germ is very rich in nutritive value. It contains a high concentration of protein, iron, and vitamins, and indeed the scutellum con-

TABLE 12. *The Chemical Composition of the Endosperm, Germ, and Bran of English Wheat*

	Gm. per 100 gm.		*Mg. per 100 gm.*		*I.U. per gm.*	*Microgrammes per gm.*	
	Protein	*Fat*	*Phytic acid phosphorus*	*Iron*	*Vitamin B_1*	*Ribo-flavin*	*Nico-tinic acid*
Endosperm							
Inner portion	8·1	0·7	8	0·5	0·1	0·4	5
Outer layers	14·6	. .	874	12·0	1·8	1·8	184
Germ							
Embryo	33	15	400	9	3	15	60
Scutellum	29	30	1,300	. .	60	. .	. .
Bran	11·4	. .	1,280	12·4	1·6	5	250

I.U. = International units.

[The values for endosperm and germ are from 'Bread' by R. A. McCance, *Lancet*, 1946 (1), p. 77, and those for bran from 'Nutrients in Wheat Endosperm' by T. Moran, *Nature*, 1945, vol. 155, p. 205.]

tains far more vitamin B_1 than any other part of the grain. The bran is rich in mineral elements and nicotinic acid, but it also contains the rough fibre and the unwanted phytic acid.

The proportions of endosperm, germ, and bran in different kinds of flour vary a good deal. The old stone-milled English flour of a hundred years ago contained practically the whole of the wheat grain except for the coarse dark-coloured bran, most of which was removed from the flour by sifting. The flour was therefore fairly white in colour. But when imported wheat began to be used in this country, the flour contained more bran and was darker in colour; the bran was not tough like that of English wheat, but so brittle that it was completely broken up by stone-milling and could not be separated from the flour. No objection was made to the dark-coloured flour, however, until white flour began to be imported from the Continent. This new flour was ground with rollers, and it was very fine and white, although made from wheat with brittle bran. The new method of roller-milling, first used in Hungary, was soon adopted by millers in the U.S.A., and the resulting white flour was sent over to England in increasing quantities. It became popular at once. The English millers were no longer able to sell their dark-coloured stone-milled flour, and were compelled to install the new roller-mills and make fine white flour, in order to stem the tide of imported flour. The change to modern white flour, which occurred about 1880, thus came in response to popular demand. The millers themselves did not want to abandon the traditional method of stone-milling, and many of them were ruined by changing over to the new process.

Unfortunately the adoption of roller-milling reduced the food value of the flour, since the fine white flour produced by this process contains practically nothing but endosperm. The old stone-milled flour, on the other hand, included the germ and some bran as well. The germ contains fat, which is apt to go rancid during storage, but our forefathers would not object to this, since they were well accustomed to eating rancid bacon fat; their plan was to disguise any unpleasant flavours with herbs and spices, and that is probably why their recipes are so much more elaborate than those we use to-day.

The removal of the germ certainly makes flour keep better, but it reduces the nutritive value. When this was realized, efforts were made to include in the flour part or all of the germ, and sometimes the bran as well, with the result that a number of kinds of brown flour appeared on the market. But 'brown flour' is a vague term that includes many different grades of flour. At one extreme there is brown flour that is made by taking white flour and adding a small amount of bran and possibly some germ as well. At the other extreme there is, in some countries, brown flour that contains the whole of the wheat grain; this type of flour was used in Eire from 1941 to 1944, but it is not obtainable in this country. Our so-called 'wholemeal' flour contains only about 92 per cent. of the wheat grain, and is here called brown flour.

Flours are classified according to the percentage of the wheat grain that they contain. Flour containing the whole wheat grain is said to be of 100% extraction; the National flour of 1942, which contains 85 per cent. of the wheat grain, is known as 85% extraction flour, and so on. White flour is usually of 70–72% extraction. As the percentage extraction rises, the flour becomes darker in colour. But although the colour becomes less attractive, the concentration of all the important nutrients except starch increases as the percentage extraction rises. Conversely, the whiter the flour, the less the nutritive value (see Table 13, p. 89). But the degree of extraction is not an exact criterion of quality. Different mills may produce flours of slightly different chemical composition, even though the degree of extraction is nominally the same. Flours of over 75% extraction are specially liable to vary in composition, because they do not all contain the same proportion of scutellum, embryo, and bran. On the other hand, presumably, white flour of low extraction could be altered in composition and made more nutritious if the small but valuable scutellum were included with the endosperm.

National (85% extraction) flour, first introduced in 1942, is an ingenious compromise between white flour and brown. It contains nearly as high a concentration of iron and vitamin as brown flour, and far more than white flour; yet it contains less coarse fibre and phytic acid than brown flour. It is true that fibre is of value in preventing constipation, but our English diets since 1939 have included so much vegetable roughage that any large addition of fibre in bread would be unnecessary and unwelcome. National flour, like all high extraction flours, contains more phytic acid than white flour; but this objection has been overcome by 'fortifying' National flour with enough calcium (usually in the form of purified calcium carbonate) to neutralize to some extent the anti-calcifying action of the phytic acid. If this had not been done, our war-time diets would almost certainly have been short of calcium.

TABLE 13. *A Comparison between Flours of Different Extraction*

	Gm. per 100 gm.				*Mg. per 100 gm.*	*I.U. per gm.*	*Microgrammes per gm.*	
	Protein	*Fat*	*Starch*	*Fibre*	*Iron*	*Vitamin* B_1	*Riboflavin*	*Nicotinic acid*
Manitoba wheat								
100% extraction	13·62	2·49	63·0	2·15	3·81	1·18	1·7	55·0
85% ,,	13·57	1·70	67·2	0·33	[1]	0·92	1·0	13·3
80% ,,	13·22	1·43	68·8	0·13	[1]	0·65	0·8	11·0
75% ,,	13·05	1·32	69·5	0·10	[1]	0·29	0·7	9·6
70% ,,	12·77	1·16	70·0	Trace	[1]	0·22	0·7	8·4
42% ,,	11·80	0·86	71·2	Trace	[1]	0·09	0·5	7·0
English wheat								
100% extraction	8·89	2·23	66·8	2·08	3·05	0·96	1·7	48·0
85% ,,	8·55	1·46	72·0	0·42	2·22	0·84	1·2	10·5
80% ,,	8·21	1·28	73·5	0·19	1·65	0·60	0·8	9·0
75% ,,	7·98	1·13	74·2	0·15	1·35	0·42	0·6	8·0
70% ,,	7·92	1·04	74·5	Trace	1·40	0·28	0·6	7·5
46% ,,	7·64	0·76	75·8	Trace	0·95	0·16	0·5	5·0

I.U. = International units. [1] These values were not determined.

The results were calculated on a 15 per cent. moisture basis. [From 'The Chemical Composition of Wheat and Rye and of Flours derived therefrom', by R. A. McCance, E. M. Widdowson, T. Moran, W. J. S. Pringle, and T. F. Macrae, *Biochemical Journal*, 1945, vol. 39, p. 213.]

In this country the flour now used for bread is partly

English and partly Canadian, and the mixture varies from time to time. In 1943, on the average, nearly half the flour used for bread was English, but by 1945 the proportion of English flour had been reduced. As can be seen from Table 13, p. 89, Manitoba flour of 100% extraction contains far more protein, and rather more iron and vitamin than English flour of 100% extraction. With white flour (70% extraction), however, there is an almost equally low concentration of iron and vitamins, whether the wheat is English or Canadian. Even if the proportion of Canadian wheat varies somewhat, it is therefore safe to say that white bread always contains less iron and less vitamin B_1, riboflavin, and nicotinic acid than brown bread or National (85% extraction) bread. Moreover, the protein of white bread is inferior in quality to that of brown bread or National bread. This does not mean that white bread cannot form the basis of an adequate diet. It can, and often did before 1939, in the days when other foods were available in abundance for those who could afford to buy them. But ordinary white bread was not good enough for our war-time diets, nor is it to be recommended for the period of 'peace without plenty' which we are now experiencing. It is advisable to continue to use high extraction flour, at least until conditions are more favourable. The adoption of the 80% extraction flour in 1945 therefore seemed to be a step in the wrong direction, but the reintroduction of 85% extraction National flour early in 1946 was clearly a blessing in disguise. If, when times improve, white flour comes back once more, it is greatly to be hoped that it will be improved by the addition of some of the more valuable parts of the wheat grain, such as the scutellum.

An alternative method of improving white flour is to add mineral salts and artificially prepared vitamins. This process of enrichment is carried out in the U.S.A., partly with the idea of supplementing the American diet as a whole, and also as a means of restoring the substances removed by milling. One difficulty about enrichment, however, is that any unknown substances that may be removed from the wheat cannot be replaced in this way. Another objection is that synthetic vitamin preparations may not be absorbed so well as those that occur naturally in foods. On the whole therefore it seems better to keep as much nourishment as possible in the flour, instead of first removing it and then trying to put it back again.

Effect of heat. Toast contains rather less water than bread, and some of the starch is changed into dextrin as toasting proceeds. When bread is fried in fat, it takes up a great deal of fat, and this adds considerably to the calorie value (see Fig. 9, p. 142).

Other Cereal Foods

Biscuits, cakes, puddings, and pastry, made with flour. The composition of these foods of course varies according to the recipe used (see p. 169). About 25 per cent. of the original vitamin B_1 is destroyed during the baking of cakes, and about 60 per cent. during biscuit-making. The addition of cooking soda (sodium bicarbonate) to scones, soda bread, &c., destroys most of the vitamin B_1 and probably the riboflavin too. Yeast, on the other hand, does not destroy these vitamins; indeed it adds slightly to the nutritive value of food, since it is itself a rich source of vitamin B_1, riboflavin, and nicotinic acid.

Wheat products other than flour. Semolina is coarser than white flour but has about the same composition, since it consists almost entirely of endosperm. Macaroni and spaghetti have a chemical composition similar to that of the flour from which they are made.

Oatmeal. Oatmeal contains more fat, iron, and vitamin B_1 than wheat but far less nicotinic acid. Rolled oats have practically the same composition as oatmeal. Only about 5–10 per cent. of the vitamin B_1 is destroyed when porridge is boiled for 30 minutes, but about 25 per cent. is destroyed when oat-cakes are made. Unfortunately oatmeal, rolled oats, and groats all have a strongly anti-calcifying action, and may therefore predispose children to rickets and bad teeth.

For this reason it is important that children who eat a good deal of oatmeal should be provided with an adequate supply of vitamin D (since this vitamin assists in the utilization of calcium) and also with plenty of calcium-containing food, such as milk and cheese. Strangely enough, the anti-calcifying action of oatmeal is far stronger than that of 100% extraction wheat flour, in spite of the fact that they both contain about the same amount of phytic acid. Wheat, however, contains the enzyme phytase, which destroys some of the phytic acid during the process of bread-making (but only if yeast is used, and not if the yeast is replaced by soda). Oatmeal contains practically none of this useful enzyme, and therefore foods made with oatmeal have a strongly anti-calcifying action.

Breakfast 'cereals'. Ready-cooked breakfast 'cereals' save housework and are often delicious, but they are a much more expensive source of calories than either porridge or bread. The chemical composition of some of them is given on page 168.

Rice. Our ordinary rice is called 'polished' rice because it is very highly refined. It contains even less protein, calcium, and iron than white flour, and very little vitamin B_1 and nicotinic acid, since these substances are removed during the milling process, just as they are when white flour is produced. Unfortunately other sources of vitamin B_1 are scarce in rice-eating countries, and beri-beri is therefore very common. An ingenious way of supplying the missing vitamin B_1 is to steam the rice in the husk before it is milled. During this process, which is known as parboiling, the vitamin B_1 and the nicotinic acid diffuse out of the husk into the endosperm, and the resulting parboiled rice contains far more of these vitamins than ordinary polished rice.

Other cereal products and similar foodstuffs. Whole barley is even richer in nicotinic acid than whole wheat, but rye is not a good source of this vitamin. Cornflour, which is made from maize, is so highly refined that it contains hardly anything else but starch; it has only a trace of protein and no vitamin at all. Sago, tapioca, and arrowroot resemble cornflour in composition, though they are not true cereals since they are not the products of grains. Soya-bean flour is also not a cereal product, for the soya bean is a legume, but it is convenient to consider it here. It is a remarkably rich source of protein, and contains a good supply of fat, calcium, iron, and vitamin B_1. It is therefore a most useful addition to diets.

Effect of heat on cereals and starchy foods. Flour and other cereal products are nearly always cooked before being eaten, and there is good reason for this: cooking makes starch easier to digest. In raw cereals and other starchy foods, the starch occurs in the form of tiny grains, which can only be seen under the microscope. These starch-grains are not easily attacked by the digestive enzymes of the body. As cooking proceeds, however, the starch takes up water and swells up into a jelly, and in this state it is easily digested. When making cornflour blancmange and when thickening gravy or sauce with flour, it is important to continue heating until the thickening is completed and all the starch is swollen up.

Sugar, Honey, Treacle, Sweets, and Chocolate

Sugar is a cheap source of calories and it is digested very readily. Glucose and the invert sugar of honey are even more rapidly available because they are absorbed straight away. Sugars are thus useful energy foods, but they contain no protein, no mineral elements, and no vitamins. Even honey is deficient in vitamins. Beet sugar is exactly the same as cane sugar, for jam-making or any other purpose, and there is no known advantage in brown sugar, so far as nutrients are concerned. Golden syrup, which is mainly composed of sugar, contains a small amount of iron, and black treacle contains a good deal of iron. Sweets consist chiefly of ordinary sugar or glucose, but toffee contains fat as well. Chocolate is a good source of calories since it contains 50–60 per cent. of sugar and about 30 per cent. of fat; it has about 5 per cent. of protein and also provides iron.

Fruit, Jam, Marmalade, and Jelly

The nutritive value of fruit lies chiefly in its vitamin C. From this point of view the best fruits are black-currants, rose-hips, strawberries, oranges, lemons, grapefruit, red-currants, gooseberries, raspberries, and loganberries; Bramley's Seedling apples contain a fair amount of vitamin C in the fleshy parts and even more in the skin. In addition, orange-coloured fruits such as peaches and apricots provide us with carotene (pro-vitamin A). Fruits also provide sugar (3–18 per cent.), roughage, and mineral elements. There is only a trace of fat in fruit (except in rare cases, such as olives and avocado pears) and hardly any protein. Fresh fruits usually contain so much water that the calorie value is almost negligible.

The stewing of fruit does not destroy much vitamin C because the acidity of the fruit has a protective action. Some of the vitamin C diffuses out of the fruit into the surrounding fluid, but this is not wasted since the fluid is consumed with the fruit. Baking in the oven has not much effect on the vitamin C of Bramley's Seedlings. When fruit is canned, the heating is done in the absence of air, and this minimizes the destruction of vitamin C. Tinned fruit, therefore, has about the same amount of vitamin C as similar fruit that has been stewed; home-bottled fruit usually contains slightly less. Dried fruits are a fairly cheap source of calories, but they contain no vitamin C when prepared by ordinary commercial methods. They contain 40–65 per cent. of sugar and 2–5 per cent. of protein, and also supply roughage and mineral elements, especially iron. Dried apricots, peaches, and prunes contain carotene (pro-vitamin A).

Jam contains a small amount of vitamin C if it is made from black-currants, rose-hips, or other fruits rich in vitamin C; but the vitamin C is slowly destroyed during storage, especially if the jam or jelly is not well set. All jams supply calories, and those containing pips and skins also supply roughage. Jam-like jellies contain no roughage and have a lower calorie value. Marmalade usually contains vitamin C since the rind of citrous fruits is an even richer source of this vitamin than the juice. In jam-making, cane sugar gives exactly the same results as beet sugar, since these two highly refined products are virtually indistinguishable. When the sugar is boiled with the fruit, some of it is turned into invert sugar, which is very readily absorbed by the body. The special character of home-made jam is partly due to the fact that it is boiled for a longer time than bought jam and therefore contains more invert sugar. The concentration of fruit in jam varies a great deal, but generally speaking home-made jam contains more than bought jam.

Table jellies are in quite a different category because they contain gelatin, whereas jams and jam-like jellies owe their setting powers to pectin. Table jellies have hardly any food value if they are made up with water, and if they are made with milk the nourishment comes from the milk, not from the jelly.

Vegetables and Salads

Most vegetables, like fruits, are a valuable source of vitamin C. Indeed, in this country during World War No. 2 when fruits were practically unobtainable, vegetables were almost our only source of this important vitamin. The salad vegetables, herbs, and other vegetables that are rich in vitamin C include nearly all green vegetables (especially kale, Brussels sprouts, cauliflower, cabbage, turnip-tops, and spinach) and also potatoes, swedes, watercress, mustard and cress, fresh parsley, tomatoes, nasturtium leaves and stems, and horse-radish. Carrots and other root vegetables, except swedes, are not so good in this respect. Swedes retain their vitamin C very well during storage but, as we shall see later, potatoes and green vegetables do not.

There is a certain amount of vitamin B_1 in vegetables, and legumes (peas, beans, and lentils) are a good source; potatoes supply a small amount of nicotinic acid. Green vegetables and orange-coloured vegetables, especially carrots, supply carotene (pro-vitamin A). Vegetables also contain a certain amount of carbohydrate, except for mushrooms which have none; cooked green vegetables usually have less than 2 per cent., but there is 20 per cent. or more in boiled potatoes and in dried legumes that have been cooked. There is practically no fat in most vegetables and hardly any protein, except in peas and beans; broad beans and fresh peas contain 4–5 per cent. of protein when cooked, and dried legumes 6–8 per cent. when cooked. Vegetables supply mineral elements, including calcium and iron, and also roughage. They contain so much water that their calorie values are low.

When vegetables are cooked in water, the fibrous cell-walls are softened. With starchy vegetables (potatoes, carrots, and other root vegetables), as with cereals, cooking makes the starch easier to digest. Carotene is not destroyed by cooking, and cooked carrots actually provide more carotene than raw carrots. Both boiling and steaming lead to a slight loss of mineral elements and vitamin B_1, but the most serious loss in the cooking of vegetables is that of vitamin C. We shall deal now with these losses in some detail.

Potatoes, new and old, and the effect of cooking. New potatoes are rich in vitamin C, and contain about the same amount of this vitamin per pound, whether they are large or small. If a small potato is allowed to grow to double its weight, it will then contain double the amount of vitamin C. It is therefore more economical to let potatoes grow to a good size, rather than lift them when they are very small and 'new'. In any case they should be freshly dug, for they lose more and more vitamin C the longer they are stored. Potatoes fresh from the soil contain the maximum amount of vitamin C, and old potatoes are a good source of this vitamin until about Christmas. After that they become less useful in this respect (see Fig. 7, p. 97).

Potatoes retain most of their vitamin C when they are boiled in their skins. When scraped or peeled and put into cold salted water and boiled, they lose about half their vitamin C; starting them in boiling water makes practically no difference to this loss, and makes it more difficult to cook the insides of the potatoes properly. Mashing causes little or no further loss, but mashed potatoes lose their vitamin C even more quickly than unmashed ones if they are kept hot before being eaten. Baking in the oven leads to a greater loss of vitamin C than boiling, but water is lost at the same time, with the result that baked potatoes contain as much vitamin C per pound as boiled potatoes do. Chipped potatoes, fried in deep fat, contain even more vitamin C per pound than boiled potatoes, because here there is an even greater loss of water than with baking. With steaming, potatoes take longer to cook than with boiling, and they lose more vitamin C.

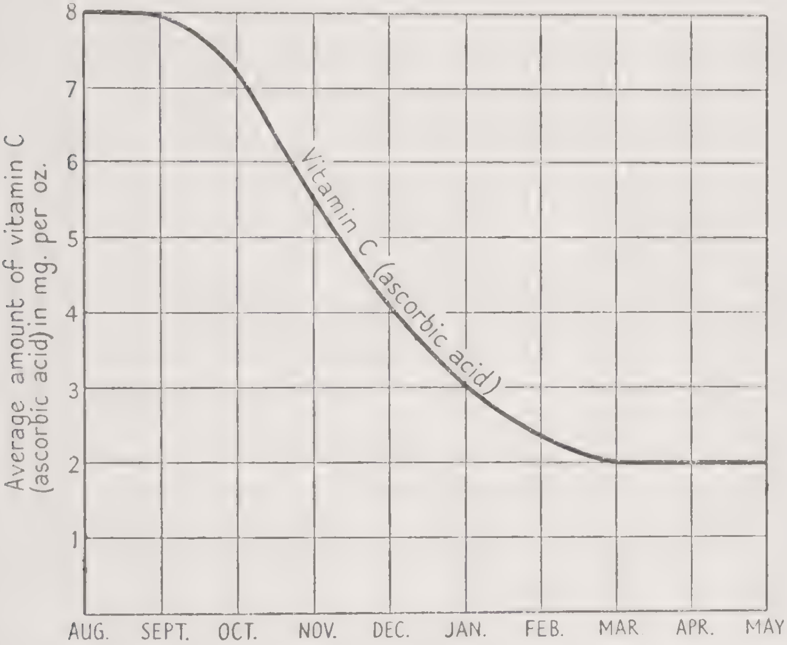


FIG. 7. Diagram showing the amount of Vitamin C in potatoes at different times of the year.

[Drawn from results given in *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

With pressure-cooking, the very high temperature leads to still greater losses. Hay-box cooking destroys all the vitamin C.

The storage and cooking of green vegetables. Green vegetables lose their vitamin C quickly during storage at ordinary temperatures, but not quite so quickly if kept in a refrigerator. As with potatoes, hay-box cooking is disastrous, pressure-cooking leads to serious loss of vitamin C, and steaming causes more loss than boiling. To minimize losses of vitamin C, the following so-called 'conservative method' should be used. Large vegetables such as cabbages should be cut across into thick slices with a sharp knife. The pieces should be dropped bit by bit into rapidly boiling water. Salt should be added but no soda. There should be the least possible amount of water in the pan, and the lid should fit well and be kept on, to prevent the pan from boiling dry. If any water is left over at the end, it should be used for gravy or soup as it contains vitamin C; but it should not be kept long before being used. The vegetables should not be overcooked. Above all, they should be served and eaten as soon as they are ready. Cooked green vegetables, like potatoes, lose their vitamin C very rapidly if they are kept hot after they have been strained, and these losses are more serious if soda is used during the cooking.

Tinned vegetables. These contain about the same amount of vitamin C as boiled vegetables of the same variety, but with tinned vegetables a good deal of the vitamin C has diffused out of the vegetable into the surrounding fluid.

Salads. If salad vegetables are served whole, or cut up with a sharp knife at the last moment, they retain all or most of their vitamin C. Grating is bad as it leads to loss of vitamin C.

Nuts

Nuts vary a good deal in composition, but they are nearly all rich in fat and have high calorie values. The fat varies from 50 to 64 per cent. (except for chestnuts which have only 2 per cent.), the protein varies from 3 to 28 per cent., and the carbohydrate from 4 to 37 per cent. They supply mineral elements including iron, and vitamin B_1. Peanuts are remarkably rich in nicotinic acid, and almonds contain a small amount. Fresh green walnuts are rich in vitamin C, and home-pickled walnuts contain this vitamin when they are fresh, but it is gradually destroyed during storage. Nuts contain a considerable amount of roughage and phytic acid.

Milk

Milk is a rich source of essential nutrients. It contains protein, fat, carbohydrate, mineral elements (especially calcium and phosphorus but not iron) and vitamins, especially vitamin A, vitamin B_1, and riboflavin. Milk also contains a small amount of vitamin D in summer, but not much, if any, in winter. If it is fresh from the cow, milk supplies vitamin C too; by the time it has been delivered, however, most of this has disappeared owing to the destructive action of light (the yellow riboflavin acts as a sensitizer). The most serious weak spot is the deficiency of iron; two trace elements, copper and manganese, are also missing, and nicotinic acid is present in only very small amounts.

A word must be said about pasteurization. According to one school of thought, pasteurization puts a premium on carelessness, and we ought to aim at producing clean, pure milk, free from tubercle bacilli, rather than take all milk, good and bad together, and pasteurize the lot. The other school of thought, to which most medical men belong, points out that a great deal of the unheated milk now consumed acts as a carrier of tuberculosis and other diseases, whereas pasteurized milk is safe. The conclusion generally reached is that children should have fresh milk of the best quality from tuberculin-tested cows, or failing this, milk that has been pasteurized or boiled. Pasteurization destroys only 10 per cent. of the vitamin B_1, and about 20 per cent. of the vitamin C. The process known as 'sterilization' is far more drastic. It destroys 30 per cent. of the vitamin B_1, and 50 per cent. of the vitamin C; moreover, it reduces the biological value of the protein. 'Sterilized' milk thus has not nearly such a high nutritive value as fresh or pasteurized milk. It is, however, popular in some parts of the Midlands, owing to its good keeping qualities.

Household milk and all other kinds of dried and condensed milk are very rich sources of protein, calcium, and riboflavin; dried milk and condensed and evaporated milk, if prepared from whole milk, also contain fat and vitamins A and D. Sweetened condensed milk provides sugar as well, and about 85 per cent. of the original vitamin C of the milk, though this is gradually destroyed after the tin has been opened.

Butter and Other Fats

Butter, margarine, lard, dripping, and other fats all have high calorie values, and margarine is one of the cheapest sources of calories. Summer butter supplies us with vitamin A and a small amount of vitamin D. Ordinary margarine contains no vitamins at all, but all our present-day English margarine is 'vitaminized' and contains vitamins A and D. Dripping contains a small amount of vitamin D. Fish-liver oils, such as cod-liver oil and halibut-liver oil, are the richest naturally occurring sources of vitamins A and D.

Medicinal Paraffin

Medicinal paraffin is not a food, and should on no account be used as an ingredient of cakes or salad dressing or any other type of food. It is not digested in the body and therefore has a laxative action, but there is a great objection to its use: it dissolves vitamins A and D and removes them from the body as it passes through.

Cheese

Cheese is a highly concentrated food with considerable nutritive value. It contains about 25 per cent. of protein and 30–37 per cent. of fat, and is rich in calcium and riboflavin.

It also contains vitamin A and a small amount of vitamin D. Cooking does not affect the nutritive value to any marked extent.

Eggs

Eggs are of great value in nutrition because they contain about 12 per cent. of both protein and fat, and are a rich source of iron, phosphorus, vitamin A, riboflavin, and vitamin D. Moreover, the yolk contains lecithin, a valuable fat-like substance. Brown-shelled eggs are no better than white ones, so far as food value is concerned, nor are eggs with deep yellow yolks superior to those with pale yolks, since the colour here is not due to carotene (pro-vitamin A). Cooking has not much effect on the nutritive value of eggs.

Dried eggs contain no less than 43 per cent. of both protein and fat. When reconstituted they have almost as high a food value as fresh eggs. They should not be mixed with liquid until the last possible moment before they are to be used. It is not safe to mix the dried egg-powder with water and then leave it for several hours, because any contaminating bacteria that are present would then multiply enormously in numbers, and might not all be killed in the subsequent cooking process.

Meat

Cooked meat contains about 20–30 per cent. of protein and is a valuable source of fat, iron, phosphorus, vitamin B_1, and nicotinic acid; pork, bacon, and ham are especially rich in vitamin B_1, and liver and kidney in nicotinic acid; moreover, liver is rich in vitamin A. Chicken and rabbit contain far less fat than beef and mutton, while goose and duck contain more. Corned beef is a cheap source of protein, but it is deficient in meat vitamins, since these are washed out during the process of manufacture.

During the cooking of meat, the protein is coagulated (set) by the heat. The lean part of the meat shrinks and squeezes out juice, but this leads to no loss of nutriment since the fluid is served with the meat or used for gravy or soup. Some of the vitamin B_1, however, is destroyed by cooking—about 50 per cent. with roasting and grilling, and about 20 per cent. with boiling, stewing, and frying.

Ready-prepared meat foods, such as meat-pies, sausages, and all kinds of potted meat, are more liable to become infected with the bacteria responsible for food poisoning than is meat itself, but nowadays the risk of infection is small. Pork sausages and other pork products should be thoroughly cooked before being eaten, in order to kill parasites. A recent outbreak of trichiniasis, involving about 500 factory workers, was traced to the use of raw sausage-meat as a filling for sandwiches; if the sausages had been properly cooked, the outbreak would never have occurred.

Fish and Shell-fish

Cooked fish contains about 12–25 per cent. of protein and is a rich source of calcium and phosphorus; it also contains nicotinic acid and small amounts of vitamin B_1 and riboflavin. Fatty fish (such as herrings, mackerel, sardines, and salmon) contain about 15 per cent. of fat and provide vitamins A and D. Silver eels may contain 30 per cent. of fat and are rich in vitamin A. Fishes with edible bones (such as sardines, and herrings baked in vinegar) are especially rich in calcium, and fish paste is rich in both calcium and iron. Fish from the sea supply traces of iodine and fluorine.

When fish is cooked, the protein coagulates and the fish shrinks and squeezes out juice, even when it is steamed. This shows that there is no truth in the old idea that steaming conserves the nutritive value. With boiling, the losses of mineral salts are even greater than with steaming because, in addition to shrinkage, there is also diffusion of soluble substances (salts, extractives, vitamin B_1, riboflavin, and nicotinic acid) from the fish into the surrounding water. If this water is thrown down the sink, as often happens, there is thus a considerable loss of nutriment when fish is boiled. With frying and baking, some of the vitamin B_1 is destroyed by the heat; but, apart from this loss, these methods conserve the nutritive value better than steaming does, and far better than boiling; shrinkage occurs during frying and baking, but the water expressed during shrinkage evaporates away, leaving behind in the fish most of the salts and extractives.

Shell-fish more or less resemble fish in composition. They are particularly rich in mineral elements, including calcium, magnesium, iron, phosphorus, and iodine.

Dehydrated Foods

Foods dried by the best modern methods are very much better than the old dried foods, both in flavour and nutritive value. To emphasize this great superiority, the new products are usually called dehydrated foods and the new process is called dehydration. During World War No. 2 a good many foods were dehydrated in order to save transport. As we have already seen, most ordinary foods contain a considerable amount of water. It has been calculated that the food annually imported into this country before 1939 must have contained three million tons of water. Hence the need for dehydration. Much shipping was saved during the war by importing eggs and milk in a dehydrated state, and by sending dehydrated foods abroad from this country to supply the needs of our fighting men. One great advantage of dehydrated foods is that they do not require refrigerated holds. Another point is that the nutritive value is conserved in a most remarkable way. Dehydrated cabbage, for instance, is rich in vitamin C. Explorers and sailors who have to live on dried foods will, in the future, be able to keep free from scurvy by eating dehydrated green vegetables, instead of having to use artificial preparations of vitamin C.

Tabloid food. Some people have an idea that scientists would like us to eat food in tabloid form; they seem to think that a few small tabloids a day could take the place of ordinary meals. Quite apart from the fact that scientists enjoy meals just as much as any other people, it may be mentioned that a day's food occupies far more space than this, even if every particle of water is removed. Enough food to yield the classical 3,000 calories, without any water at all, would weigh about a pound and a half, and take up as much space as about a dozen eggs.

Proprietary Foods

Generally speaking, patent foods are expensive luxuries. They are often convenient to use in cases of illness, but there is often an ordinary food or a home-made dish that will do just as well. The objection to many patent foods is that their high price may bear little or no relation to the cost of the materials used. Moreover, some patent foods are far from being what they claim to be. The absurd claims made in the advertisements of such products ought, by themselves, to be enough to make people suspicious. But the simple faith of the general public is astonishing. Many people attribute marvellous properties to patent foods which are in reality ordinary foods disguised by attractive trade names.

Edible yeast and yeast extracts. Marmite, which is a flavoured extract of yeast, contains vitamin B_1 and riboflavin, and is a rich source of nicotinic acid. 'Edible food yeast' is an even richer source of these three vitamins.

Meat extracts. Extracts of beef, chicken, &c., are useful for dyspeptics and invalids who have no appetite, because they promote the flow of gastric juice and in this way assist digestion. Until recently it was thought that they had no further function, but it has now been found that they are a rich source of riboflavin and nicotinic acid. A teaspoonful (10 gm.) of beef extract may contain as much riboflavin and nicotinic acid as two ounces of roast beef. This does not mean that meat extracts contain the whole value of the meat, as is sometimes stated in advertisements; they contain neither the valuable protein of the meat nor the fat.

Peptonized foods. Peptonized foods are of great value in the treatment of certain diseases, for in these preparations the complex proteins of the food have been broken down into simpler substances, such as peptones.

Malted foods. The malted foods are another class of manufactured foods that are to some extent predigested, though here it is not protein but starch that is broken down. Malt extract is chiefly composed of maltose and dextrin, but it also contains diastase, an enzyme which converts starch into dextrins and maltose. Malt extract is therefore useful for dyspeptics, both as a source of easily digested carbohydrate (maltose and dextrin), and also as a source of diastase, which assists in the digestion of starch. Moreover, malted foods presumably contain riboflavin and nicotinic acid, since malted cereals are a rich source of these vitamins. Malt extract with cod-liver oil contains a small amount of vitamins A and D, but is not nearly such a rich source of these vitamins as cod-liver oil itself. The food value of some malt extracts is increased by the addition of such substances as dried milk or eggs. For example, one brand of malted milk contains 50 per cent. of dried milk, 26 per cent. of flour, and 23 per cent. of malt.

Vitamin preparations. For most people, patent vitamin preparations are neither necessary nor advisable. It is far better to spend the money on good food such as milk, cheese, eggs, fruit, vegetables, fish, and meat. These foods not only supply us with vitamins but also with other nutrients, some of which are probably as yet unknown. Moreover, it is highly probable that the vitamins naturally occurring in foods are better absorbed by the body than are synthetic vitamin preparations. A good diet provides an adequate amount of all the vitamins that we require, except for vitamin D; this is needed in extra amounts by children, and can be obtained from cod-liver oil. Vitamin preparations, however, are of great value in medicine, and for people who have to live on very restricted diets.

Beverages

Tea and coffee. Neither tea nor coffee by itself provides us with protein or calories, and indeed for years it was thought that they had no real food value at all. But recent research has shown that tea provides us with a small amount of riboflavin, and coffee with a small amount of nicotinic acid. A breakfast cup of tea provides about 10 microgrammes of riboflavin. The stimulating action of both tea and coffee is due to an alkaloid called caffeine. When boiling water is poured on to tea-leaves, the caffeine and volatile oil are practically all extracted in the first minute or two, but bitter tannin continues to diffuse out of the leaves for a long time. The longer the liquid remains on the leaves, the more tannin it will contain. China tea contains less tannin, less caffeine, and less volatile oil than either Indian or Ceylon tea. The amount of tea and coffee that can be drunk without injury to health is very much an individual matter, but nervous people and dyspeptics should take these beverages sparingly.

Cocoa. Cocoa contains far less alkaloid than either tea or coffee and therefore has less action on the nervous system. It provides carbohydrate, fat, protein, and iron, but in such minute amounts as to be almost negligible. The calorie value of cocoa powder is fairly high, but even a large cup of cocoa (as a beverage) provides only about 40 calories if the cocoa is mixed with water. If sugar or milk are added, the additional calories of course come from them and not from the cocoa itself.

Lemonade and other fruit drinks. Fresh home-made lemonade is a good source of vitamin C. Since the coloured part of the rind is very rich in vitamin C, it should be peeled off and boiled for a few minutes in water to extract the vitamin C; the sugar can be dissolved in the hot water at the same time, but this mixture should be cooled before the lemon juice is added. Bought fruit drinks save trouble and may be very refreshing, but they usually contain no vitamin C. Concentrates of orange-juice, however, are in a different category. If they are made by reputable firms they are carefully tested, and are often guaranteed to contain a definite amount of vitamin C.

Alcoholic drinks. We have seen that alcohol, like glucose, is rapidly absorbed in the body without having to undergo any process of digestion, and that moderate amounts of alcohol stimulate the flow of gastric juice and thus assist digestion. Moreover, it has recently been found that beer is a good source of riboflavin and nicotinic acid, and also provides a small amount of vitamin B_1.

When alcohol is burnt in the body, it produces 7 calories a gramme, but it is doubtful whether this energy is of much use to the body, except in cases of extreme cold when a rise in temperature is required. Under ordinary conditions, even in winter, the body produces more heat than is needed to keep the temperature up to blood heat. Alcohol cannot be used as fuel for muscular work, though it is capable of 'sparing' some of the fat or carbohydrate used for this purpose; but there is probably little or no net gain of energy, because alcohol dilates the capillaries of the skin (hence the flushed appearance) and this leads to an extra loss of heat. For this reason it is a bad thing to drink alcohol on a wintry day immediately before going out. The popular notion that alcohol fortifies people against cold weather is thus a dangerous fallacy.

The amounts of alcohol and sugar in various beverages are given in Table 14, p. 108.

Note on Food Handling

It is not generally realized that foods provide nourishment not only for mankind, but also for the micro-organisms which set up disease in man. Dry food, such as flour, is not a suitable medium for the growth of these infections; but wet foods, such as milk and meat, form an excellent medium for the development of harmful bacteria. Occasionally these bacteria are originally in the food; in most cases of food poisoning, however, the food is infected by the people who handle it. This can be prevented by proper food hygiene. Unfortunately, standards in this country deteriorated greatly during the war, owing to the lack of trained personnel, the shortage of wrapping materials, and so on. Now that the

TABLE 14. *The Amount of Alcohol and Sugar in Various Beverages*

	Alcohol, *c.c. per 100 c.c.*	*Sugar,* *gm. per 100 c.c.*
Wines:		
Bordeaux:		
Vin ordinaire	7	0·1
Claret	9	0·2
Californian claret	9	0·15
Graves	9	0·4
Sauterne, dry	12	1·0
Sauterne, sweet	12	2·3
Burgundy:		
Average	11	0·2
Australian	11	0·3
Beaune	11	0·3
Californian	11	0·2
Chablis	9	1·2
Pommard	12	0·2
Champagne, dry	12	1·9
Hock	8	0
Italian wine, dry	10	0·3
Madeira	15	2·0
Marsala	16	3·5
Moselle	8	0·25
Port	17	6·8
Sherry, dry	17	2·0
Sherry, sweet	17	4·0
Spirits:		
Brandy, old	45	0
Gin, dry, pre-War	30	0
Rum, pre-War	43	0
Rum, Jamaica	69	0
Whisky, pre-War	40–45	0
Whisky, post-War	20–25	0
Liqueurs, &c.:		
Absinthe	45–55	0
Benedictine	40–50	33
Brandy	45	0
Chartreuse	43	34
Crème de Menthe	48	28
Curaçao	30–45	29
Kümmel	35–55	31
Vermouth	14–16	9·5
Beers, &c.:		
Ale or beer	4–5	3–5
Cider	5–6	0·7–2·0
Porter or stout	5	4–6

[From *The Diabetic Life*, by R. D. Lawrence (J. and A. Churchill, Ltd.), 1944.]

war is over, it is to be hoped that an improvement will soon be noticeable, for foods are often handled nowadays with a truly appalling lack of care. Foods should never be touched by hand unless this is unavoidable. Moreover, people who handle food should be taught the principles of food hygiene and, above all, they should be selected on the basis of health.

CHAPTER VII

EVERYDAY MEALS

> Every man who has been worth a fig in this world as poet, painter, or musician, has had a good appetite and a good taste. Ah, what a poet Byron would have been had he taken his meals properly!
>
> THACKERAY.

MOTHERS of large families and people in charge of institutions cannot be expected to weigh out individual diets and calculate how much protein, fat, &c., is eaten by each member of the household. Yet, however busy they are, they should make an effort to provide good meals for those under their care. The best kinds of food to buy depend to some extent on the ages, occupations, and tastes of the people concerned, and on the amount of money available. But there is one general rule: a reasonable amount of each of the essential nutrients should be included in the diet every day. The following nutrients are of special importance: protein, calcium, iron, vitamin A, vitamin B_1, riboflavin, nicotinic acid, vitamin C, and (where children are concerned) vitamin D. The amounts of carbohydrate and fat require less attention.

The calorie value of the diet generally adjusts itself when people have enough food to eat. Under starvation conditions, however, the daily allowance of calories becomes a matter of prime importance. So far, in this country, in spite of our rigorous system of rationing, we have not yet been seriously short of calories; our errors in diet are usually errors of quality, not quantity. A diet may have the proper calorie value and still lack several of the nutrients that are essential for the maintenance of health.

Foods containing Protein

Protein, which is required by children for growth, and by both children and adults for body-building purposes, is present in rich supply in the following foods: milk of all kinds, including dried household milk, dried whole milk, condensed milk, and evaporated milk; cheese of all kinds except cream cheese; lean meat of all kinds, including bacon, ham, liver, kidney, poultry, game, and corned beef; fish of all kinds; eggs and dried eggs; soya-bean flour. Bread contains less than half as much protein as lean meat, yet it is an important source of protein, because we eat such large quantities of bread. Peas, beans, and lentils when cooked contain about as much protein as bread, but potatoes and other vegetables contain far less.

Foods containing Carbohydrate and Fat

Carbohydrate has about the same value in the body whether it is taken as starch or sugar. Starchy foods include bread, biscuits, cakes, and other foods made with flour, oatmeal, macaroni, cornflour, rice, sago, tapioca, &c.; potatoes, peas, beans, and lentils also provide starch. Sugary foods include sugar itself, and honey, treacle, golden syrup, jam, marmalade, sweets, chocolates, dried fruits, bananas, and other fruits. Fat is obtained from butter, margarine, dripping, lard, suet, olive oil, cooking fats, and also from cheese, meat, fatty fish (such as herrings, kippers, bloaters, mackerel, fresh salmon, tinned salmon, sardines, and eels), soya-bean flour, eggs, and milk.

Both carbohydrates and fat serve mainly as fuel in the body, and the proportion of one to the other in the diet is largely a matter for people to settle for themselves. Fats produce more calories than an equal weight of carbohydrates, but they are more expensive and not so easy to digest. People who have difficulty in dealing with fat should cut down their fat allowance and eat starchy or sugary foods instead. According to the nursery rhyme,

Jack Sprat could eat no fat,
His wife could eat no lean;
And so, between them both, you see
They licked the platter clean.

But this probably only refers to the fat of meat. It is quite possible that Jack Sprat ate a good deal of butter even if he refused meat-fat. Still, there is no doubt that people vary in their tolerance to fat.

When fats are eaten in moderate amounts with other foods they are usually well digested, well absorbed, and well utilized. An excess of fat, however, may set up ketosis (biliousness) unless enough carbohydrate is eaten at the same time. It is therefore advisable not to have too much rich fatty food at any one meal. With fried fish, for instance, it is better to have boiled potatoes than fried 'chips', unless you have extra carbohydrate, such as bread, to balance the fat.

Foods containing Mineral Elements

Calcium is needed by children for their bones and teeth, and by adults for many purposes. Milk is a rich source, and diets deficient in milk are nearly always deficient in calcium. There is abundant calcium in all kinds of milk, including dried 'household' milk, dried whole milk, condensed milk, and evaporated milk. Other good sources of calcium are cheese of all kinds, fish with edible bones (such as sprats, whitebait, sardines, and herrings baked in vinegar), fish-paste, and green vegetables (except spinach, in which the calcium is rendered unavailable by oxalic acid).

Iron, which is needed especially by women and adolescent girls, can be obtained from liver, kidney, and other kinds of meat, and from sprats, sardines, fish-paste, oatmeal, brown bread, National bread, green vegetables, peas, beans, and soya flour. Chocolate, dried apricots, dried peaches, and treacle are also fairly rich in iron. Moreover, an appreciable amount of iron can be added to food by the use of non-stainless steel knives, mincing machines, iron pans, and other iron-containing utensils. Curry is very rich in iron, but such a small amount of curry can be eaten at a meal that the extra iron obtained is extremely small; indeed, there is three or four times as much iron in cooked liver as there is in curried beef or mutton.

Iodine, to ward off goitre, can be obtained from iodized salt, and from sea-fish, which also supplies the minute trace of fluorine that appears to be necessary for the development of good teeth.

Foods containing Vitamins

Vitamin A (*or carotene*). This can be obtained from the following sources: liver, kidney, and fatty fish such as eels, herrings, kippers, bloaters, sardines, and tinned salmon; eggs (fresh or dried), cheese, milk, and butter (especially in summer when the cows eat grass), and vitaminized margarine; orange-coloured vegetables and fruits such as carrots (which, in this respect, are better cooked than raw), tomatoes (fresh, cooked, bottled, or tinned); apricots and peaches (fresh, dried, or tinned); and green vegetables (raw or cooked). In addition, cod-liver oil and halibut-liver oil are very rich sources of vitamin A.

Vitamin B complex. Vitamin B_1 is supplied by pork, ham, bacon, liver, kidney, oatmeal, brown bread, National bread, soya flour, peas, beans, lentils, and many other foods. Riboflavin can be obtained from liver, milk (including dried 'household' milk, dried whole milk, condensed milk, and evaporated milk), cheese, eggs (fresh or dried), brown bread, and National bread. Nicotinic acid is supplied by liver and other kinds of lean meat (except corned beef), beef extracts, fish, brown bread, National bread, and potatoes. 'Edible food yeast' is a very rich source of the vitamins of the B complex; Bemax is rich in vitamin B_1, and marmite in nicotinic acid.

Vitamin C. This is provided by a number of fruits and vegetables. The best fruits for this purpose are blackcurrants (stewed, bottled, tinned, or purée), rose-hips (as syrup, jelly, or jam), strawberries and gooseberries and raspberries and loganberries (fresh, stewed, bottled, or tinned). Pears, grapes, plums, greengages, and damsons are not well supplied with vitamin C; most apples too are disappointing in this respect, but Bramley's Seedlings contain a good deal of vitamin C and they do not lose much of it when they are baked in the oven; their peel is rich in this vitamin, and the old plan of putting the apple peel on the top of the apple charlotte may therefore increase the nutritive value. Green vegetables are rich in vitamin C, especially kale, cabbage, Brussels sprouts, turnip-tops, and cauliflower (cooked or tinned in every case); but they lose a good deal if they are kept too long before being cooked, or cooked in too much water or for too long a time. With green vegetables (cooked or tinned), potatoes, and other vegetables that contain vitamin C, the most serious loss occurs when they are kept hot after being cooked and strained. To avoid this loss they should be served and eaten as soon as they have been cooked. Freshly prepared salads provide vitamin C, especially if they contain watercress, mustard and cress, nasturtium leaves, and tomatoes (fresh, bottled, or tinned); lettuce is not so good in this respect. Fresh parsley should be used as much as possible, since it is very rich in vitamin C; dried parsley, however, contains none. New potatoes are a rich source of vitamin C, and old potatoes are a good source until about Christmas. After this they become less and less useful from this point of view (see Fig. 7, p. 97), and it is therefore important in the early months of the year to serve kale and other green vegetables until new potatoes and summer fruits are again in season.

Vitamin D. This can be obtained in small amounts from herrings, kippers, bloaters, mackerel, tinned salmon, eggs (fresh or dried), summer butter, and vitaminized margarine. Cod-liver oil and halibut-liver oil are rich sources. An alternative way of obtaining vitamin D is to produce your own, free of charge, by exposing the skin to sunlight. Sun-bathing should of course be undertaken very gradually; at first only a small area should be exposed to the sun for a short time, and oil should be applied to the skin to prevent blistering.

Note on Protective Foods

Foods rich in vitamins are sometimes called protective foods, since they protect us against deficiency diseases. It may be mentioned, however, that Dr. McCollum, who invented this term some ten years ago, used it in a more restricted sense. He considered that the American diet, based as it was on bread, potatoes, meat, and sweets, was deficient in calcium and vitamin A, and that it could be improved by adding to it more milk, milk products, and green vegetables. He therefore called these foods protective foods, and later added fruit to his list; some other Americans also include eggs as protective foods. In this country, however, the term is used more comprehensively; for instance, Professor Mottram's list of protective foods consists of dairy foods, special fruits, vegetables, salads, fatty fish, liver, and kidney. Some lists include whole cereals. Meat is not usually included, though it has a good claim to be, since it is a rich source of several vitamins; in this country in 1934–8 meat provided us with over half our total nicotinic acid and over a quarter of our vitamin B_1 and riboflavin.

Nutritive Values Summarized

A rough idea of the amounts of the most important nutrients in bread, eggs, meat, and other common foods, is given in Table 15, p. 116. The plus signs represent degrees of merit. A single plus sign (+) indicates a fairly good source of the nutrient concerned; two plus signs (+ +) indicate a good source, three (+ + +) a rich source, and four (+ + + +) an even richer source. A slight plus (sl. +) indicates that the food contains only a small amount of the nutrient, and a blank space indicates a negligible amount or none at all. In Table 15, if we look down the column for a single nutrient, we can see which foods contain it most abundantly. We can also see which foods contain the most nutrients. Thus eggs have plus signs in eight of the ten columns, while sugar has them in only one. It should perhaps be explained that the plus signs represent relative but not absolute values. If we say that a food is rich in protein and calcium, we do not mean that it contains the same concentration of both these nutrients; we mean that in each case it is rich as compared with other foods.

TABLE 15. *Summary of the Nutritive Value of Food in Terms of Calories, Protein, Calcium, Iron, and Vitamins*

	Calories	Protein	Calcium	Iron	*Vitamin A*	*Vitamin B$_1$*	*Riboflavin*	*Nicotinic Acid*	*Vitamin C*	*Vitamin D*
Bread, cakes, &c.										
White bread	++	+		sl.+		sl.+	sl.+	sl.+		
Brown bread	++	+		+		++	+	+		
Biscuits and pastry	+++	+								
Oatmeal	+++	++		+		++		+		
Fruit cake	++	++	+	+	sl.+	+				
Blancmange and custard	+		+							
Jelly										
Eggs, milk, butter, &c.										
Eggs	++	+++	+	++	++	sl.+	+++			+
Milk	+++	++++	++++		++	++	+++			
Cheese	++++	++++	++++		++		++			
Butter	++++				++++					sl.+
Vitaminized margarine	++++				+++					+
Dripping	++++									
Meat										
Beef, mutton, and lamb	++	++++		+		+	+	++		
Chicken	++	++++		+		+	+	+++		
Pork	+++	++++		+		+++	+	++		
Bacon and ham	+++	++++		+		+++	+	++		
Liver	++	++++		+++	++++	++	++++	++++		
Kidney	++	++++		+++	+	+	++	++		
Sausages	++	++		+		sl.+	sl.+	+		
Fish										
Herrings and kippers	++	+++	+	++	+	+	+	+		++
Tinned salmon	++	+++	+	+	+	+	+	+++		++
Sardines	++	+++	+++	++	+	+	+	++		++
Sprats and whitebait	++	+++	++++	++		+	+	+		
White fish	+	+++	+				+	+		

	Calories	*Protein*	*Calcium*	*Iron*	*Vitamin A*	*Vitamin B_1*	*Ribo-flavin*	*Nicotinic Acid*	*Vitamin C*	*Vitamin D*
Vegetables										
Potatoes	+					+		sl.+	++	
Peas, beans, and lentils	+	+	+	sl.+	sl.+	++	+	sl.+		
Carrots			+		+++	+				
Other root vegetables			+			+				
Tomatoes					++	+			++	
Green vegetables			+		++	+			++++	
Watercress			++	+	++	+			++++	
Fruit and nuts										
Oranges and lemons					sl.+				++++	
Black-currants			+	sl.+					++++	
Bananas	+								sl.+	
Apples									sl.+	
Dried apricots and peaches	++		+	++	+++			+		
Other dried fruit	++		+	+	sl.+			sl.+		
Peanuts	+++	+++	+	+		+++		++++		
Other nuts	+++	++	+	+		+				
Sugar, jam, &c.										
Sugar	+++									
Honey	+++									
Black treacle	++		+++	++						
Jam	++									
Marmalade	++								sl.+	
Milk chocolate	+++	+	++	+						
Edible food yeast	++	++++	+	+++		++++	++++	++++		
Tea, Lemonade, &c.										
Tea (no milk or sugar)							sl.+			
Black coffee								sl.+		
Cocoa (no milk or sugar)	+			sl.+						
Fresh lemonade									+++	
Cod-liver oil					++++					++++

Roughage

In addition to the proteins, vitamins, &c., which we have just mentioned, most people also require a regular supply of roughage to keep the digestive system in proper working order and thus prevent constipation. The following foods are rich in roughage: brown bread, oatmeal, vegetables, fruits, nuts, and jam that contains pips and skins.

Cost and Nutritive Value

It is difficult to economize on food, because several of the fairly expensive foods are so important that they must on no account be left out of the diet. Milk is a case in point. It may not be cheap, but it is such a rich source of nutriment that it should be given a generous place in the diets of people of all ages. 'Household milk' is much cheaper than fresh milk and contains a good supply of nearly all the original nutrients of the milk, except that it contains no fat and no vitamin A or D, since it is prepared from skim milk. Eggs, like milk, also contain many valuable nutrients, and should always be bought if possible; dried eggs, which are somewhat cheaper, have nearly as high a food value as fresh eggs. Butter is dearer than milk as far as food value goes, and cream is very much dearer still.

Fortunately there are a number of foods which are not expensive to buy and which have a high food value. For instance, we may mention National bread, cheese, herrings, cheap white fish, and the cheaper kinds of meat. Poultry, game, expensive cuts of meat, expensive white fish, and fresh salmon, are all luxuries rather than necessities. Expensive fruits and vegetables such as grapes, pineapples, and asparagus must also count as luxuries; but kale, cabbage, potatoes, carrots, swedes, watercress, parsley, oranges, and many other fruits and vegetables can usually be obtained fairly cheaply and provide excellent value for the money. Dried fruits, cheap nuts, and dried peas, beans, and lentils are also well worth buying. People who have a garden or allotment can save money by growing fruit and vegetables; moreover, they can have their vegetables absolutely fresh, which means that they will contain far more vitamin C and will taste much nicer than if they had been stored for some time.

Ready-prepared breakfast foods, biscuits, cakes, and pastries are usually not much better than bread so far as food value is concerned, but they are much more expensive. If money is scarce, it is therefore better to spend it on bread than on made-up cereal foods, in order to keep enough money over for milk, eggs, meat, vegetables, and other foods rich in nutritive value.

Water

The daily intake of water for an adult is usually about 2½ pints in temperate regions, including the water in tea, coffee, and other beverages, but there is no reason why far more than this should not be drunk. In tropical climates extra water has to be drunk to compensate for the extra loss due to perspiration. The question whether we should drink with meals or between meals can be answered best by saying that it is a safe rule for healthy people to drink when they are thirsty. There is no objection to taking moderate amounts of liquid with meals. A hot drink last thing at night often encourages sleep.

Foods for Hot Weather and Cold Weather

People often imagine that more food is required in cold weather than in hot weather, but this is not so, except in very extreme conditions, such as those encountered by Arctic explorers. Even in cold weather our bodies produce more heat than is required to keep us warm, and the problem in winter is not how to produce more heat, but how to prevent the loss of the heat that we already produce; we can do this by wearing suitable clothes. In hot weather, on the other hand, we want our bodies to lose as much heat as possible, and therefore we ought to wear fewer and lighter clothes. We require just as much food in hot weather as in cold, but not necessarily the same type of food. In hot weather, salads can take the place of hot vegetables; and cold meat or fish or cheese can replace hot and greasy dishes. There should also be plenty of refreshing drinks in hot weather.

Meal-times

The number of meals we have in a day depends chiefly on custom. The usual Western practice of having three good meals a day seems to work well for most people. Moreover, a light snack during both morning and afternoon has recently been sanctioned by physiologists. Elevenses and afternoon tea are now considered blameless.

The times of meals must depend to a large extent on individual occupation, but it is advisable to keep to definite meal-times because our digestive powers depend a good deal on the formation of regular dietetic habits. In addition there are one or two practices that should be avoided. For instance, it is unwise to take much muscular exercise in the morning before taking food. Another bad habit is to have a heavy meal immediately before going to bed.

Meals for One

It is well known that women tend to have wretchedly inadequate meals when they have no-one to cook for but themselves. And World War No. 2 has shown that this is equally true of men. One man, when his wife was away, took all his meat ration as corned beef, to save the bother of cooking. There are several objections to this type of meal. Cold food has to be warmed up to blood heat in the body, and this wastes energy. Moreover, since cold food lacks the appetizing smell of a hot meal, it does not stimulate the secretion of the gastric juice to anything like the same extent. Another serious objection to many solitary meals is that they contain neither fruit nor vegetables, and are therefore deficient in vitamin C. In this country a good many cases of 'bachelor scurvy' have recently been discovered among men living alone on bread, margarine, and cheese.

Large-scale Catering

Large-scale catering is a highly responsible occupation, whether the meals are for hospital patients, schoolchildren, or other groups of people in canteens, restaurants, and so on. Every effort should be made to provide foods that are rich in the essential nutrients. It is also most important that the food should be cooked in an appetizing way and served attractively. Special attention should be paid to vitamin C, since this is the danger-point in communal cooking. Fruit should be provided frequently, and also fresh salads, in which the ingredients are served whole or have been freshly cut up but not grated. Great care should be taken in the cooking of vegetables. If ordinary large-scale methods of cooking are used for green vegetables, as much as nine-tenths of the vitamin C may be destroyed. But this loss can be cut down in several ways. In the first place, the vegetables should be as fresh as possible so that they have the maximum amount of vitamin C at the start. As in domestic cooking large green vegetables should be cut across into thick slices with a sharp knife, and the pieces dropped into rapidly boiling water containing a little salt but no soda. If the vegetables are cooked in batches, the same cooking-water should be used over and over again. If this is impossible, there is another way of preventing the vitamin C from being nearly all washed out into the cooking-water; the tough outer vegetable leaves, which are usually discarded, should be boiled in water briskly for ten minutes, and strained off, and this cooking-water used for the edible part of the vegetable. As in domestic cooking, vegetables should not be overcooked, and should be served as soon as possible after being cooked.

Personal Peculiarities

Those who are responsible for ordering meals should bear in mind the question of individual taste and see that there is plenty of variety, and that alternative dishes are served. There is no need to prove by scientific reasoning that it is foolish of people to eat food that disagrees with them. There are indeed a few unfortunate people who are allergic to certain special foods; for instance, some people suffer from skin eruptions if they eat shell-fish. Such effects are probably due to protein poisoning. The particular protein concerned apparently escapes the usual process of digestion and gains access to the blood-stream. It is well known that many proteins act as poisons when they are injected into the blood, and this is probably the explanation of these idiosyncrasies of diet.

Not only is it unwise to eat food that you cannot digest, but it is also physiologically unsound to eat food you dislike very much, because the secretion of the gastric juice depends to some extent on pleasurable sensations. The Victorian idea that it was a virtue in children to eat food they did not like, and an offence against discipline to pull faces over it, was based on a false view of nutrition. At the same time, it is a mistake to be too faddy about food. People who restrict their diet to a very few foods may easily miss some important nutrient.

It may be remarked that some people remain well although their diets do not conform to physiological standards. Even if there are no apparent ill-effects, however, there may be a subtle undermining of health, for deficiency diseases are notoriously difficult to detect in the early stages. By the time that obvious symptoms appear, it may be too late to effect a complete cure.

With elderly people, simple easily digested foods should be provided, because digestive troubles are especially likely to occur. There are, it is true, some old people who have remarkable powers of digestion. They can eat all kinds of unsuitable food and yet remain in good health. But these are exceptional cases. Generally speaking, the digestive powers diminish in old age.

CHAPTER VIII

DIETS FOR MOTHERS AND CHILDREN

Train up a child in the way he should go: and when he is old, he will not depart from it.
PROVERBS.

Diets for Expectant Mothers

SINCE the diet of the expectant mother has a profound effect on the development of the child, it is doubly important that she should have suitable food. During the first half of pregnancy there is no need to increase the quantity of the food, but great attention should be paid to the quality. Extra protein is required and can be obtained from milk, cheese, eggs, meat, or fish. These foods all supply essential vitamins as well, and milk and cheese provide the necessary calcium. Vitamin C should be obtained from oranges or special fruit juice concentrates and also from salads and cooked vegetables. Vitamin D, which is essential for the proper development of the baby's bones and teeth, should be obtained from cod-liver oil or halibut-liver oil, both of which can be obtained in the form of capsules, or from a synthetic preparation. Iodized salt should be used instead of ordinary salt, both for cooking and for table use; it tastes exactly like ordinary salt and is about the same price. Additional iron is needed too. This should be obtained from liver, and other iron-containing foods, and also from the chemist's in the form of ferric ammonium citrate. The dose recommended by Dr. Paterson is: Ferri et Ammon Cit. grains xx, three times daily. The diet should consist of plain and simple foods. Rich pastry and fried foods should be avoided since too much fat encourages morning-sickness; sugar, on the other hand, helps to prevent it.

During the second half of pregnancy the diet should continue along the same lines as before, except that about 20 per cent. more food should now be eaten (see Table 9, p. 78).

Breast-feeding

It cannot be too strongly emphasized that the best food for a baby is mother's milk. Breast-feeding is not only cheaper, simpler, and cleaner than artificial feeding, but it is also safer. On the average, breast-fed children are far healthier than those brought up on substitutes. Mothers should therefore make a great effort to feed their babies, at any rate for the first six months. At least nineteen women out of twenty are capable of feeding their babies successfully, and both doctors and nurses should encourage them to do so. The mother's milk rarely, if ever, disagrees with the baby. If the baby does not flourish, it usually means that the mother's milk is not plentiful enough. Many mothers find that their milk disappears when they get up and resume their ordinary activities. But this may be only a temporary disturbance. The mother should rest as much as possible and pay great attention to diet (see Lactation, p. 78).

Nursing mothers. The mother's diet should be the same as before the birth of the child, but more water and other fluids should be drunk, and more food should be eaten to allow for the formation of the mother's milk. The extra food should include plenty of protein because the milk itself contains protein, and, moreover, the wear and tear of the tissues is increased by nursing. Needless to say, there is no scientific basis for the old-fashioned idea that the baby will develop indigestion if the mother eats fruit. It is quite certain, however, that if the mother has a poor diet, deficient in protein, mineral elements, or vitamins, her health will be undermined, and the child will suffer too.

The breast-fed baby. Nowadays babies usually have five or six meals in 24 hours; they are fed at intervals of either three or four hours during the day, and not at all at night. When the time-table has been arranged it should be followed scrupulously. Once a week the child should be weighed. In some cases it is advisable to find out how much milk the child is receiving. This can easily be done by the mother herself, if she can secure a suitable balance. It is only necessary to weigh the fully dressed baby immediately before and after a meal; the difference between the two weights shows the amount of milk obtained at the meal. The weighings should be repeated at every meal for a 24-hour period, because the amount of milk received varies according to the time of day.

TABLE 16. *The Average Amount of Milk obtained by a Healthy Breast-fed Baby*

	Approximate amount of milk obtained in 24 hours
At the end of the 1st week . . .	10–16 oz.
During the 2nd week	13–18 ,,
During the 3rd week	14–24 ,,
During the 4th week	16–26 ,,
From the 5th to the 13th week . . .	20–34 ,,
From the 4th to the 6th month . . .	24–38 ,,
From the 6th to the 9th month . . .	30–40 ,,

[From *Holt's Diseases of Infancy and Childhood* by L. Emmett Holt and R. McIntosh (D. Appleton-Century Company), 1940.]

The amount of milk obtained in 24 hours can then be compared with the average value for a child of the same age (see Table 16).

Cod-liver oil, orange juice, and swede juice. Even breast-fed babies need extra vitamin C and vitamin D, which can be obtained from orange juice and cod-liver oil respectively. The cod-liver oil is usually given before meals—half a teaspoonful twice a day; a single drop of halibut-liver oil twice a day can be given instead. The orange juice, two or three teaspoonfuls, is given between meals; if it is unobtainable, guaranteed rose-hip syrup or black-currant juice can be used instead, or freshly prepared swede juice. Tomato juice is not so rich in vitamin C. The swede juice is prepared as follows. Wash a swede, peel it, and grate it finely. Put the grated pulp into a piece of butter muslin, and squeeze it over a cup. The juice can be brought to the boil and then cooled, without losing much vitamin C. It should be used within 2 hours.

Artificial Feeding

If a mother is unable to feed her child, or if she is medically advised not to do so, artificial feeding has to be adopted. In olden times when this situation arose, a foster mother was usually employed, for this was then the best way of saving the baby's life. Nowadays artificial methods of feeding are far more successful than they were, and foster mothers are no longer necessary. In some countries, however, breast milk is collected from healthy mothers, after a thorough medical examination, and given to other people's babies.

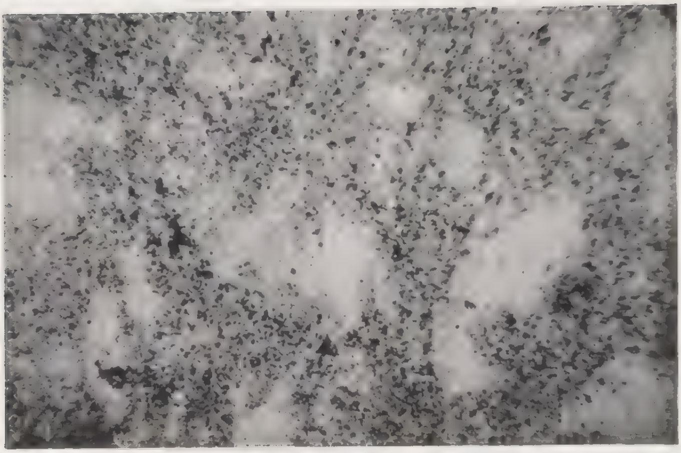
The choice of a baby food of course rests with the doctor in charge of the case, but it may be helpful to give some indication of the choice of foods available. Further information can be obtained from *Hutchison's Food and the Principles of Dietetics* by V. H. Mottram and G. Graham.

Note on vitamins. Before discussing baby foods, it must be emphasized that artificially fed babies need extra vitamins even more than breast-fed babies do. They should therefore have a daily allowance of orange juice and cod-liver oil, as described above.

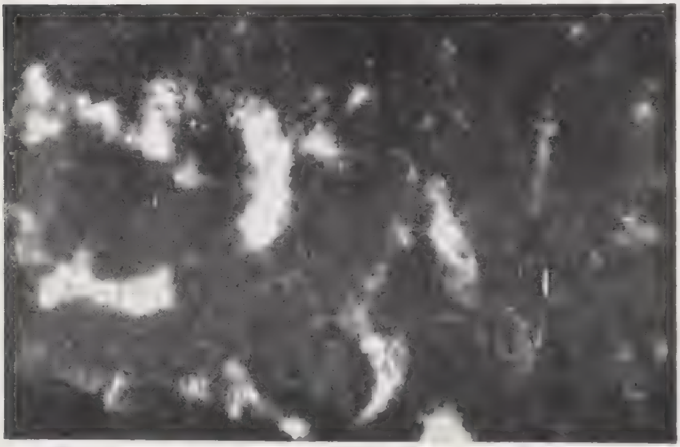
Baby Foods based on Fresh Cow's Milk

Pasteurization and boiling of milk. Most doctors recommend that milk for babies should be either pasteurized or boiled, since unheated milk is very liable to contain harmful bacteria.

Cow's milk and human milk compared. The most obvious substitute for mother's milk is cow's milk, and this is sometimes the best as well as the cheapest of artificial baby foods, if it is suitably modified before use. The difficulty about unaltered cow's milk is that it is not usually well digested by babies. The composition is not the same as that of human milk (see Table 17, p. 127). In cow's milk there is far more protein than in human milk, and there is a different proportion between the two types of protein, namely, lactalbumin which is easy to digest, and casein which is not so easy. In



(*a*) Curds from human milk



(*b*) Curds from cow's milk

FIG. 8. Photomicrographs of curds from (*a*) human milk, (*b*) cow's milk.

human milk, more than half of the protein is the easily digested lactalbumin, but in cow's milk there is four or five times as much casein as lactalbumin. This great mass of casein forms a tough clot in the baby's stomach, whereas the clot from mother's milk is loose and easily broken up (see Fig. 8). Cow's milk is more digestible when it has been boiled, or if citric acid is added, or if it is modified in some other way. Three methods of modification will now be considered briefly.

TABLE 17. *A Comparison between Human Milk and Cow's Milk*

	Human milk	*Cow's milk*
Protein	1–2 per cent.	3–4 per cent.
Fat	3–4 ,,	3·5–4·5 ,,
Sugar	6–7 ,,	4–5 ,,
Mineral salts	0·1–0·2 ,,	0·7 ,,
Water	87–88 ,,	87–88 ,,
Reaction	Alkaline	Acid

[From *Hutchison's Food and the Principles of Dietetics*, by V. H. Mottram and G. Graham (Edward Arnold & Co.), 1940.]

Humanized cow's milk. If enough water is added to cow's milk to reduce the amount of casein until it is the same as that in human milk, the milk will be easier to digest, but it will now be deficient in lactose, fat, and lactalbumin. Lactose can easily be added, it is true, and the concentration of lactalbumin can be adjusted by diluting the milk with whey instead of water; and the fat can be brought up to the required standard by adding cream, if it is obtainable. By the careful manipulation of milk, cream, lactose, and whey (or dried whey and water), it is possible to prepare a modified milk which has about the same concentration of lactose, fat, lactalbumin, and casein as human milk; a little lime-water is usually added, as cow's milk tends to be slightly acid. Milk prepared in this way is known as 'humanized' milk. The disadvantage is that it is laborious to prepare. Dried humanized milk, which is made up simply by adding water, will be considered later, under the heading of Proprietary Baby Foods.

Milk with added water and sugar. A simpler method of modifying milk is to add water and sugar. Most doctors think that ordinary sugar is quite as good as lactose, but that babies with digestive troubles should have a mixture of dextrin and maltose instead of ordinary sugar. The amounts of milk, water, and sugar are varied according to a 'formula', which is usually based on the weight of the baby. Dr. Paterson bases his calculations on what he calls the 'expected weight', namely the weight at birth plus 1 oz. for every day for the first 100 days (excluding the first 10 days) and 4 oz. a week after this until the age of 1 year. For every pound of 'expected weight' he recommends a 24-hour ration of $1\frac{3}{4}$ fluid ounces of cow's milk plus a level teaspoonful of sugar plus enough water to make up the fluid to the daily requirement for the age in question. A rough estimate of the daily fluid requirement can be obtained from the values given in Table 16, p. 125.

Lactic Acid Milk. Another way of making cow's milk more digestible is to add lactic acid. This precipitates the casein in extremely fine flocculent curds which are easily digested by babies. Lactic acid milk is not difficult to prepare at home, and in certain places it can be bought ready-prepared. It is also possible to buy a dried preparation of lactic acid milk, which is made up simply by adding water.

The Milk of Asses and Other Animals

The milk of an ass was once thought to be an excellent baby food, but it is not used nowadays since it has been found to contain less fat than human milk and to be no better than suitably modified cow's milk. Mare's milk contains rather more protein than human milk, and goat's milk contains even more protein than cow's milk.

It may be mentioned that there is an interesting correlation between the concentration of protein in the mother's milk and the normal rate of growth of the young animal. The more protein there is in the milk, the more quickly the young animal grows. A lamb receives milk with 6·5 per cent. of protein in it, and takes only 10 days to double its weight; a calf receives milk with 3·3 per cent. of protein and doubles its weight in rather less than 7 weeks; a baby obtains only 1·5 per cent. of protein from its mother's milk, and takes about 6 months to double its weight.

Condensed Milk

The only type of condensed milk that makes a good baby food is unsweetened condensed whole milk, often known as evaporated milk. Condensed skim milk is seriously short of fat and should never be used. All sweetened condensed milks are also unsuitable (whether full-cream or skim) because they contain far too much sugar; they are too sweet to drink unless a good deal of water is added, and this degree of dilution reduces the concentration of protein and fat too much. Babies fed on sweetened condensed milk often put on weight quickly, but they become flabby-looking and unhealthy. Unsweetened condensed milk, however, is a good basis for a baby food. If it is diluted with water until it has the same composition as fresh cow's milk (as directed on the tin) it can then be 'modified' by adding sugar and more water. It is usually digested with ease, but it is not as convenient to use as a dried baby food because it soon goes bad after the tin has been opened.

Proprietary Baby Foods

These are nearly always used nowadays when babies have to be artificially fed. They have many advantages. They are easy to prepare, free from disease germs, and have a taste which most babies appreciate. But two points should be borne in mind. First of all, the food must fulfil the physiological requirements, and secondly it must suit the baby. Curiously enough, there are some physiologically inadequate foods that appear to suit babies very well. They contain so little protein and fat that they are easily digested. The child is free from digestive troubles, but it is being slowly starved.

Baby foods should be judged by the standard of dried human milk, which has approximately the following composition:

Protein	12·8	per cent.
Fat	29·9	,,
Lactose	55·6	,,
Mineral salts	1·7	,,

The concentration of protein, fat, and sugar in baby foods should be about the same as in dried human milk. The protein should be of animal, not vegetable, origin, and should consist of lactalbumin and casein, preferably in the proportions present in human milk. The fat should be milk fat. In order to resemble human milk, the sugar should be lactose (milk sugar), but some doctors think that maltose suits babies better.

The artificial food that most nearly approaches the standard of dried mother's milk is cow's milk which has been suitably modified before drying. When the correct amount of water is added, the composition closely resembles that of mother's milk. Several such preparations are available. They are called by various trade names, usually with the word 'humanized' added, to indicate that they are approximately equivalent to human milk. Some of these foods also contain added iron, vitamin D, and so on. Analyses and notes on the composition of most of the well-known baby foods are given in *Hutchison's Food and the Principles of Dietetics*, by V. H. Mottram and G. Graham, and in *Modern Methods of Feeding in Infancy and Childhood*, by D. Paterson and J. F. Smith. In actual practice, dried milk does not seem to need modification as much as fresh milk. During desiccation the casein undergoes some change which makes it more digestible, and dried whole milk, with or without added sugar, often proves to be a satisfactory baby food.

Besides the baby foods we have been considering, there are a number which have a basis of dried milk with additions of such substance as vegetable protein or malted flour. Like the dried milk foods, they are made up by simply adding water. Some of these foods may be useful for individual cases, but the foods prepared from milk and milk-products alone are generally preferable.

There are also several carbohydrate foods which have to be mixed with cow's milk instead of with water. Often the milk would be better without the addition of the patent food. The final mixture contains too much carbohydrate and too little protein, with the result that the baby does not build up firm new flesh but becomes fat and flabby. These carbohydrate foods are therefore quite unsuitable for babies, although they may be perfectly all right for older children.

Children from 6 Months to 2 Years old

By the time babies are about six months old they should have some food that is rich in iron, since milk is deficient in this element, and the baby's original reserves of iron need replenishing after the first six months. The iron can be supplied as egg-yolk; a teaspoonful of raw egg-yolk can be beaten up in milk, or part of the yolk of a lightly boiled egg can be mixed with a little milk and given in a spoon. Another way of supplying iron is to give a purée made of kale, cabbage, or Brussels sprouts, or other green vegetable, but not spinach; the objection to spinach is that it contains oxalic acid, which precipitates some of the calcium of the food and renders it unavailable.

The change from an all-milk to a mixed diet should be made very gradually, and most doctors recommend that babies should be given small amounts of liquid food other than milk by the time they are about 5 months old, if they have reached the weight of 15 lb. Bone and vegetable broth is often advocated, but Professor McCance has found that its nutritive value is disappointingly low; it is a poor source of iron, it contains far less calcium than milk even if vinegar is added during the preparation, and its only protein is gelatin—a very incomplete derived protein (see Table 1, p. 6). Egg-yolk in milk is far more nourishing than bone broth, or bone and vegetable broth. Mashed vegetables can gradually be included in the diet—potatoes, or any green vegetable except spinach; carrots are not digested at all well by babies, and even with older children they often pass right through the body unchanged. Starchy foods can be given next, in the form of gruel, or as thickenings for soups. For these purposes there are a number of suitable preparations made from cereals. (When oatmeal products are used, it is particularly important to see that the baby has plenty of milk and enough cod-liver oil; otherwise the phytic acid might hinder calcification.) Tender pieces of cooked meat and fish can also be included in the menu, and soft stewed fruit. Crusts of bread and rusks should be given to encourage mastication. The daily cod-liver oil and orange juice should of course be continued, and the dose increased slightly.

From the age of 1 onwards, children should have three meals a day and possibly a light supper as well. For breakfast a child between 1 and 2 years old can have a small helping of some suitable cereal food with sugar and milk, the yolk of a soft boiled egg with bread and butter, and milk to drink. For dinner there can be mashed potatoes and mashed green vegetables with a tender piece of cooked meat or fish, or occasionally minced liver or grated cheese; this can be followed by milk pudding or baked custard with fresh or stewed fruit, and water to drink. At tea-time there can be bread and butter with honey or jam, and milk to drink, and for supper an apple. The daily ration of orange juice and cod-liver oil should be given at some fixed time every day.

Diets for Older Children

When the child grows older, there should be a variety of fruits, salads, and vegetables, and plenty of milk, eggs, cheese, meat, and fish including herrings and other fatty fish. Oatmeal products should only be given with ample milk or some other rich source of calcium. Highly flavoured substances, such as curry, mustard, and pepper, should be avoided, and the whole diet should consist of simple foods. Alcohol should never be given to children. It is also a mistake to give them tea or coffee until they are at least 12 years old. Cocoa, chocolate, and similar preparations made with milk are more suitable for children than either tea or coffee. If children get hungry between meals they should be given fruit or milk. The habit of sucking sweets or chocolates between meals is bad for the teeth, and makes children lose their appetites and not take their meals properly. Sweets should be given at the end of a meal, and the children should clean their teeth immediately afterwards.

Protein, carbohydrate, and fat. Children need a higher proportion of protein in their diets than adults do. When they are 8 years old they need as much protein as their mothers, and by the time they are 11 they need as much as their fathers. Adolescents need both more protein and more calories than adults (see Table 9, p. 78).

The proper balance between carbohydrate and fat cannot be rigidly fixed, but it is not a good plan to give children much rich fatty food. Children, like adults, develop ketosis (biliousness) if their diets contain too much fat and not enough carbohydrate; they are unable to burn all the fat completely in their bodies, since this needs a good supply of carbohydrate. The result is that these children become pale and irritable and may even lose weight. When an attack of ketosis occurs, they feel upset and have no appetite. They should be given a very plain diet with plenty of sugary and starchy foods, until they are well again. In order to prevent further attacks, even when they are well they should have no rich pastry or fried foods, but plenty of fruit, potatoes and other vegetables, bread, honey, jam, and either barley sugar or boiled sweets. Since these children often look thin, people sometimes make the mistake of giving them extra butter and other fatty foods to make them fatter; as a matter of fact, they need less fat and more starch or sugar. On the other hand, some children have too much carbohydrate. This tends to make them fat and lethargic.

Mineral elements and vitamins. All through the years of childhood foods rich in calcium, iron, and vitamins should be included in the diet. Most of these nutrients are needed in higher proportions in the diets of children than of adults (see Table 9, p. 78). Calcium is best obtained from milk, and, if possible, children should have at least a pint of milk a day. Adolescent girls should have plenty of liver and other foods containing iron, and iodized salt instead of ordinary salt. Fresh fruit, green vegetables, and new potatoes should be given when obtainable, to supply vitamin C. Most of the other vitamins will be supplied if the diet includes milk, eggs, butter, meat including liver and kidney, and fish including fatty fish. But vitamin D occurs in such small amounts in ordinary foods, however, that it is necessary for children in temperate climates to have an extra supply. The best way to provide this is to continue the daily dose of cod-liver oil or halibut-liver oil. If children start taking cod-liver oil when they are very young, they nearly always like it; if not, they will probably be able to take halibut-liver oil instead. Failing this, there are a number of commercial preparations containing vitamin D; if these are used, it is important to keep to the prescribed dose, since overdoses may be harmful.

Likes and dislikes. Many people, when they look back on their childhood, have unhappy memories of being forced to eat food they did not like. We are all anxious to save our own children from this experience, and the more we know of their real needs, the easier it will be for us to devise diets that are not only adequate but also appetizing.

If a child does not like a food such as milk, which is so valuable that it cannot be left out of the diet, every effort should be made to serve it in different ways until at last it becomes acceptable. Some children like cold milk better than hot, while others prefer milk flavoured with chocolate or cocoa; some children refuse boiled eggs but accept scrambled eggs, and so on. Liver can be disguised if necessary by mincing it and flavouring it with parsley or onions. If possible, it is better to give children an alternative dish, rather than try to force them to eat something they do not like.

At the same time it must be remembered that when a child makes difficulties over meals the trouble may not lie in the food at all. The child may actually like the food and yet refuse to eat it. Nervousness in children and the desire to create a sensation may manifest themselves in this way, and the wise parent or nurse must bring to these difficulties not only a knowledge of diet but also, what is always necessary, a real sympathy and understanding for the individual child.

CHAPTER IX

DIETS FOR SPECIAL CASES

> Though thousands hate physic, because of the cost
> Yet thousands it helpeth, that else should be lost.
> Good broth and good keeping do much, now and than
> Good diet with wisdom best comforteth man.
>
> TUSSER.

THE regulation of the diet is an important factor in the treatment of many diseases. Diabetes is a case in point, but we do not propose to consider it here, because the dietetic treatment of diabetes has to be linked up with insulin therapy. A full account of diets for diabetics is given in *The Diabetic Life* and *The Diabetic A.B.C.*, both by R. D. Lawrence. Diets suitable for many other kinds of patients can be found in *Hutchison's Food and the Principles of Dietetics*, by V. H. Mottram and G. Graham, and in *Modern Dietetic Treatment*, by M. Abrahams and E. M. Widdowson. Here we shall confine ourselves to a brief survey of diets for convalescents, and for people suffering from constipation, diarrhoea, gout, and obesity.

Convalescence

Great attention should be paid to diet during convalescence. When people are ill the body tissues waste away, and a considerable amount of body protein is lost. This is especially true of patients suffering from bone-fractures or burns, and those recovering from operations. The protein lost in these cases has to be made good by suitable dieting. If the diet does not contain enough protein, the restoration of the body tissues is slowed down. The first essential for convalescents is therefore an ample supply of protein-rich foods, such as eggs, milk, fish, and meat. Eggs are particularly good because they are so rich in essential amino-acids (see Table 1, p. 6). Fruits and vegetables should also be included in the diet to supply vitamin C. Easily digested dishes should be prepared, and the food should be made as palatable and attractive as possible, since convalescents often have little or no appetite. Individual taste should of course be taken into consideration.

Constipation

Perhaps the best example of a disorder that commonly yields to dietetic treatment is constipation. In all but a few exceptional cases, constipation is due to the partial failure of the peristaltic movements of the large intestine. These movements can be stimulated by roughage, and the dietetic treatment of constipation therefore consists in eating plenty of foods rich in roughage. The best foods for this purpose are brown bread, all kinds of fruit and vegetables, porridge and other foods containing oatmeal, and jam with pips and skins, such as home-made black-currant jam. The amount of roughage in a number of fruits and vegetables is given in Table 18, p. 138. It is also a good plan for constipated people to drink a good deal of water, either hot or cold. Coffee is usually beneficial, but it is better to avoid strong tea and also alcoholic drinks, except cider which acts as a laxative. Regular habits are, of course, essential for the prevention of constipation. Over-eating should be avoided, and plenty of exercise should be taken if possible.

Diarrhoea

It is frequently assumed nowadays that all civilized people suffer from constipation, but this is far from true. Indeed, some people have a strong tendency to diarrhoea; the movements of their intestines are not sluggish but over-active and very easily stimulated. Diarrhoea occurs in these people very readily, especially when they are in warm enervating places. Suitable dieting is generally effective. The amount of roughage in the diet should be reduced; white bread is therefore preferable to brown, and both fruits and vegetables should be eaten sparingly. Artichokes should be avoided as they often cause diarrhoea. The diet should contain plenty of milk, cheese, meat, milk puddings, and hard-boiled eggs. Tea and cocoa usually have a beneficial effect, but coffee tends to make the diarrhoea worse.

TABLE 18. *The Percentage of Unavailable Carbohydrate (Roughage) in some Fruits and Vegetables*

	Percentage of unavailable carbohydrate in edible portion		*Percentage of unavailable carbohydrate in edible portion*
Dried fruits (raw)		*Vegetables (raw)*	
Apricots	24·0	Parsley	9·1
Figs	18·5	Mustard and cress	3·7
Prunes	16·1	Watercress	3·3
Peaches	14·3	Spring onions	3·1
Dates	8·7	*Vegetables (cooked)*	
Sultanas	7·0	Haricot beans, boiled	7·4
Raisins	6·8	Spinach, boiled	6·3
Currants	6·5	Fresh peas, boiled	5·2
Fresh fruits (raw)		Butter beans, boiled	5·1
Medlars	10·2	Baked beans	5·1
Black-currants	8·7	Celeriac, boiled	4·9
Red-currants	8·2	Brussels sprouts, boiled	4·8
Raspberries	7·4	Dried peas, boiled	4·8
Blackberries	7·3	Broad beans, boiled	4·2
Quinces	6·4	Broccoli tops, boiled	4·2
Loganberries	6·2	Leeks, boiled	3·9
Cranberries	4·2	Spring greens, boiled	3·8
Damsons	4·1	Carrots, boiled	3·1
Gooseberries	3·5	Savoy cabbage, boiled	3·1
Bananas	3·4	Runner beans, boiled	3·0

[Compiled from results given in *The Nutritive Value of Fruits, Vegetables, and Nuts*, by R. A. McCance, E. M. Widdowson, and L. R. B. Shackleton (H.M. Stationery Office), 1936.]

Gout

Gout is sometimes amenable to dietetic treatment. An ordinary mixed diet contains very small amounts of substances known as purine derivatives, which are absorbed by the body and converted into uric acid. Normally the uric acid is excreted, but some people are unable to excrete it properly, with the result that deposits of uric acid accumulate in the joints and tissues and give rise to gout. In cases of gout it is therefore advisable to cut down the amount of purine in the diet, in order to try to prevent the excessive formation of uric acid in the body; for certainly the greater part of the uric acid in the body comes from the purine in our food.

TABLE 19. *The Percentage of Purine in some Foods*

Meat, poultry, game, and eggs	*Percentage of purine nitrogen in edible portion*	*Fish and shell-fish*	*Percentage of purine nitrogen in edible portion*
Sweetbread, stewed	0·43	Herring roe (soft), fried	0·48
Heart, roast	0·17	Whitebait, fried	0·34
Liver, fried	0·14	Sprats, smoked	0·25
Kidney, fried	0·14	Sardines, tinned	0·23
Pheasant, roast	0·10	Herrings, fried	0·17
Goose, roast	0·10	Mussels, boiled	0·15
Veal, roast	0·09	Bloaters, grilled	0·13
Mutton, roast	0·08	Mackerel, fried	0·10
Beef, roast	0·07	Salmon, tinned	0·10
Chicken, roast	0·07	Kippers, baked	0·09
Bacon, fried	0·07	Whiting, fried	0·09
Rabbit, stewed	0·06	Trout, steamed	0·09
Duck, roast	0·06	Haddock, fried	0·08
Pork, roast	0·05	Halibut, steamed	0·07
Ham, boiled	0·05	Cod, fried	0·06
Tongue, stewed	0·05	Hake, fried	0·06
Corned beef	0·04	Crab, boiled	0·06
Brain, boiled	0·04	Plaice, fried	0·05
Tripe, stewed	0·02	Sole, fried	0·05
Eggs, boiled	0·01	Oysters, raw	0·04

[Compiled from results given in *The Chemical Composition of Foods*, by R. A. McCance and E. M. Widdowson (H.M. Stationery Office), 1946.]

In order to reduce the amount of purine in the diet, gouty people should have practically no meat, meat extracts, meat soup, poultry, game, or fish. Sweetbread, liver, kidney, herrings, sprats, and sardines should be specially avoided as they are rich in purine. The only kinds of meat that contain relatively small amounts of purine are corned beef, tripe, brains, and oysters (see Table 19, p. 139). Brown bread contains more purine than white. Tea, coffee, and cocoa used to be on the forbidden list, but are now generally allowed by doctors, since it is suspected that their particular form of purine (methyl purine) does not give rise to uric acid. The following foods can safely be taken, since they are practically free from purine: milk, cream, cheese, butter and other fats, sugar, honey, jam, and marmalade; white bread, biscuits, vegetables, eggs, and nuts are also allowable because they do not contain much purine. Gouty people should eat sparingly, take plenty of exercise if possible, and drink plenty of water. They should drink little or no alcohol since this makes gout worse.

Although meat and fish are rich in purine derivatives, there is no reason to blame these foods for the original onset of gout. With healthy people the consumption of relatively large amounts of purine-rich foods does not necessarily lead to the accumulation of uric acid because, as we have said, these people have no difficulty in getting rid of the excess of uric acid. Some people remain free from gout although they eat a great deal of meat and fish. This is true of the Eskimos in Greenland. They live largely on meat and fish, and their diets contain an amazing amount of purine, yet gout is unknown among them.

Obesity

Obesity is another condition in which dietetic measures are often successful. The causes of obesity are various and somewhat obscure. Some people put on weight far more quickly than others. Many cases of obesity, however, are due to over-eating combined with lack of exercise. The patent medicines advertised as cures should always be avoided. There is no drug that reduces the body-weight without at the same time damaging the health. Many of the quack remedies are harmless and useless, but some reduce the weight by ruining the digestion. Thyroid extract should never be taken except under medical supervision.

The dietetic treatment of obesity is based on the unfortunate fact that if the food contains a greater amount of fat or carbohydrate than is needed to meet the calorie requirements, the excess is stored in the body as fat. To prevent the accumulation of body-fat, it is therefore necessary to cut down the daily allowance of fat and carbohydrate, that is to say, to have a diet with a low calorie value. The protein in the diet should be decreased only slightly if at all, and the mineral elements and vitamins not at all. The calorie value (which, for the obese, means the fattening value) of some common foods is shown graphically in Fig. 3, p. 41.

The general rules for the obese are as follows. They can have without restriction clear soup, lean meat, white fish (so long as it is not fried), green vegetables, salads, and fresh fruit. Milk and eggs are allowed in moderate amounts, and bread, butter, margarine, fatty fish, potatoes, peas, beans, and root vegetables in small amounts. Pork, ham, meat-fat, cream, sugar, sweets, cakes, pastry, and puddings are forbidden altogether. Fried foods should also be avoided because they contain so much fat. Fig. 9, p. 142, shows that some pieces of bread, which had an initial calorie value of 270, took up enough fat to send the calorie value up to 888, when they were fried in fat for 2 minutes. Table 20 (p. 143) gives an example of a diet based on these principles.

Dieting should be continued until the weight approximates to that considered normal for the given height, age, and sex. It is generally considered advisable to reduce fairly gradually, and aim at losing no more than a pound or possibly two pounds a week. People who try to reduce more quickly have to eat so little food that they are in danger of missing some dietary essential. Even when enough weight has been lost, fattening foods should still be eaten sparingly, or the weight will increase once more.

Foods for the obese should not be highly flavoured, as this serves to encourage appetite. It is often recommended that nothing should be drunk at meal-times. This probably helps, because people eat less food if they take their meals

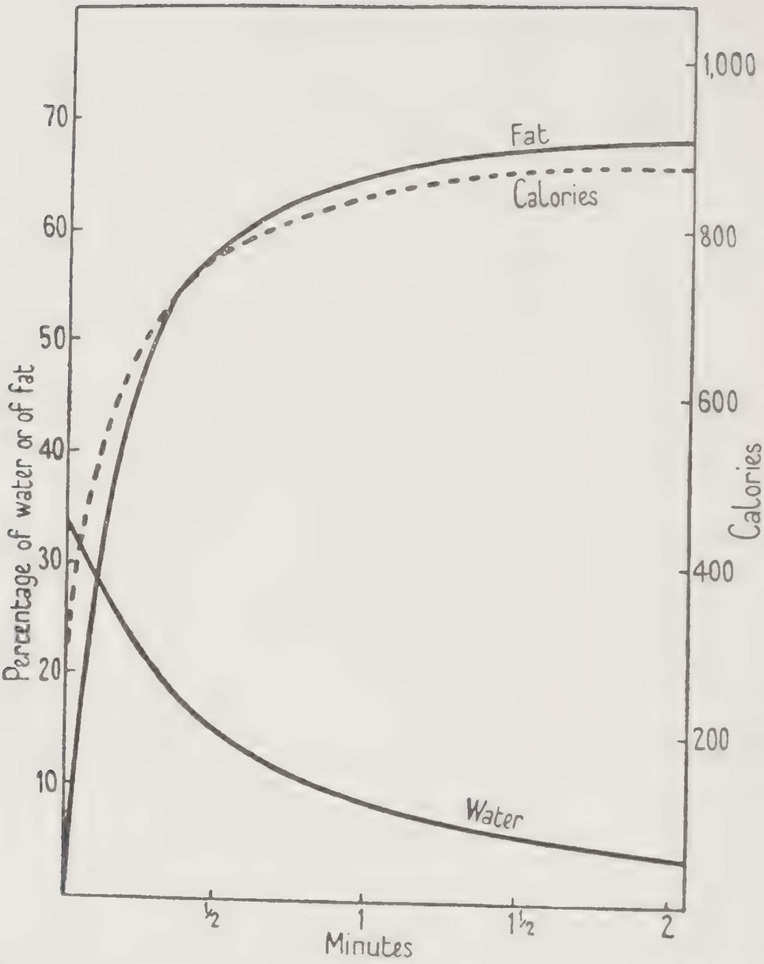


FIG. 9. Diagram showing the uptake of fat by bread during frying, and the consequent increase in calorie value.

Five pieces of bread with a total weight of 100 grammes (3½ ounces) were fried in fat for two minutes. The bread lost most of its water but took up so much fat that the calorie value, which was originally 270, rose to 888. [From *The Nutritive Value of Fruits, Vegetables, and Nuts*, by R. A. McCance, E. M. Widdowson, and L. R. B. Shackleton (H.M. Stationery Office), 1936.]

without drinking. But the amount of fluid drunk has no direct effect on loss of body-fat. If meals are eaten without drinking, plenty of fluid should be taken between meals to make up the usual amount. By drinking very little total fluid you may reduce your weight owing to loss of body-water; but this does not cure obesity, since it does not reduce the body-fat.

TABLE 20. *Diet for Cases of Obesity*

Breakfast.	One egg, boiled or poached. Bread, white or brown, two thin slices. Butter or marmalade or jam, very thinly spread. Tea or coffee (not coffee essence) with milk to taste but no sugar.
Dinner.	Meat (lean), rabbit, chicken or steamed fish, medium portion. Gravy without fat or thickening. Green leaf vegetables, marrow, or tomatoes (not fried) as much as desired. Raw fruit.
Tea.	Bread, two thin slices. Butter or jam very thinly spread. (Butter for the day must not exceed ¾ oz.) Marmite or meat extract to spread if desired. Salad, and vinegar if desired. Tea with milk to taste but no sugar.
Supper.	Cheese, sardines, salmon, herring, or kipper, small portion, or White fish or smoked haddock, medium portion. Bread, one thin slice, or two unsweetened biscuits. Raw fruit or salad if desired. Tea or coffee (not coffee essence) with milk to taste but no sugar.

The approximate composition of this diet is as follows:

Carbohydrate 100 gm.
Protein 50 gm.
Fat 50 gm.

It yields about 1,070 calories.

[From *Modern Dietary Treatment*, by M. Abrahams and E. M. Widdowson (Baillière, Tindall, & Cox), 1940.]

Some obese people take massage treatment; this reduces the weight of the masseur but not that of the patient. Taking exercise, however, is good for the obese, if they can stand it, since it increases the muscular tone as well as reducing the weight. But exercise is not to be compared with dieting as a weight-reducer. A great deal of exercise is needed to work off even a small amount of calorie-producing food. You have to walk three or four miles, or play games for half an hour, to use up as much fuel (200 calories) as you get from two or three slices of bread and butter (1½ ounces of bread yields 114 calories, and three-eighths of an ounce of butter yields 85 calories).

Although carefully restricted diets are necessary for very fat people, they are definitely harmful for those who are not suffering from obesity. People whose weight is not much above the normal for their height and age should on no account try to reduce their weight. The modern craze for slimming is always foolish and frequently disastrous.

CHAPTER X

FOOD HABITS AND DIETING SYSTEMS

While we single out several dishes and reject others, the selection seems but arbitrary, or upon opinion; for many are commended and cryed up in one age, which are decryed and nauseated in another.

SIR THOMAS BROWNE.

THE food we eat depends largely on habit. Each country has its own traditional foods, and for certain people one of the joys of travel is the change in diet it affords. On the other hand, many people dislike unfamiliar kinds of food, as Belloc pointed out:

Alas! what various tastes in food
Divide the human brotherhood!
Birds in their little nests agree
With Chinamen, but not with me.
Colonials like their oysters hot,
Their omelettes heavy—I do not.
The French are fond of slugs and frogs.
The Siamese eat puppy-dogs.

. . . . .

And all the world is torn and rent
By varying views on nutriment.

Occasionally it happens that there are individuals who cannot keep well on the ordinary conventional diet of the community in which they live; they are compelled to seek a special diet in order to maintain their strength. A knowledge of the scientific principles of nutrition will be of the greatest help to people in this position. Other people adopt special systems of diet for religious or ethical reasons. Systems of this kind should obviously be brought into line with the known scientific requirements, or ill health will follow.

Vegetarianism

A word must be said about vegetarianism, which is probably the most popular of all dietetic systems. Adequate diets can easily be planned for the so-called vegetarians who eat such good animal foods as eggs, milk, butter, and cheese. Diets of this kind suit some people well—for instance, gouty people, since the purine content is low. It is, however, more difficult to plan a good diet for strict vegetarians, who eat no food of animal origin. These people have to eat an inconveniently large amount of food in order to obtain as much protein as they require, because fruits and vegetables and even cereals contain far less protein than animal foods. This large bulk of food puts a strain on the digestive system and may prove irritating since plant foods contain so much roughage.

Food Fads

Besides those who find it necessary to adopt dieting systems for health purposes or for ethical reasons, there are also a number of people who adopt new diets in order to be in the fashion or to create a sensation. These are the real food faddists. One dieting craze follows another. The diet may be a foolish one, and it may be based on a hopeless misunderstanding of physiology, but if it is 'put across' with a suitable mixture of pseudo-scientific jargon and emotional appeal, it will have plenty of adherents. Some of these diets are said to cure almost any kind of disease, and it is naïvely claimed of one that it will make you fatter if you are too thin, and thinner if you are too fat.

Disinterested science makes less extravagant claims but is a safer guide.

TABLES SHOWING SOURCES OF VITAMIN A, VITAMIN B_1, RIBOFLAVIN, NICOTINIC ACID, VITAMIN C, AND VITAMIN D

The values in these tables refer to English foods, except that with nicotinic acid a good many American values have been used. In each table the foods are arranged in order of merit. It should, however, be mentioned that foods vary a good deal in composition, especially as regards vitamin content. The values in the tables should therefore be regarded as averages.

SOURCES OF VITAMINS

VITAMIN A AND CAROTENE

	Vitamin A I.U. per 100 *gm.* (3½ *oz.*) *of food, raw or cooked (edible portion)*
Halibut-liver oil, average	16,000,000
Cod-liver oil (Ministry of Food)	100,000
Liver, sheep	45,000
Liver, ox	15,000
Liver, pig	5,000
Liver, calf	4,000
Empire butter	4,000
Dried eggs	3,000
Vitaminized margarine	2,000
Cheese, Cheddar type	1,300
Dried whole milk	1,070
Fresh eggs	1,000
Kidney	1,000
Condensed milk, whole, sweetened	370
Condensed milk, whole, unsweetened, U.K.	370
Condensed milk, whole, unsweetened, U.S.	320
Tinned sardines	270
Tinned salmon	250
Heart	200
Kippers	180
Bloaters	160
Dehydrated meat	150
Herrings	150
Red herrings	140
Fresh milk, May to November	140
Fresh milk, December to April	70
Dripping	100
Toffee	100
Beef	50
Veal	50
Mutton	50
Lamb	50
Sheep's head	50
Tinned herrings	30
'Household' milk (dried skim)	30
Condensed milk, skim, sweetened	20

I.U. = International units.

[The value for halibut-liver oil is from *The Biological Standardisation of the Vitamins*, by K. H. Coward (Baillière, Tindall, & Cox), 1938, and all the other values are from *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

SOURCES OF VITAMINS

VITAMIN A AND CAROTENE (*continued*)

	Carotene[1] *I.U. per* 100 *gm.* (3½ *oz.*) *of food, raw or cooked* (*edible portion*)
Carrots, September onwards	20,000
Tinned carrots	20,000
Parsley	13,000
Spinach	13,000
Carrots, July and August	10,000
Turnip tops	10,000
Kale	8,000
Tinned spinach	7,000
Watercress	5,000
Dried apricots	5,000
Lettuce	4,000
Tomatoes	3,000
Tinned tomatoes, solid pack	3,000
Dried prunes	2,500
Cabbage	900
Apricots	750
Peaches	750
Asparagus	700
Tinned asparagus	700
Spring onions	700
Leeks	700
Runner beans	600
French beans	600
Green peas	500
Tinned garden peas	500
Baked beans in tomato sauce	500
Tinned apricots	500
Tinned peaches	500
Brussels sprouts	400
Plums	400
Greengages	400
Tinned damsons	360
Blackberries	300
Oranges	300
Gooseberries	200
Cherries	200
Tinned plums	200
Tinned greengages	200
Parsnips	200
Dried peas	200
Split peas	200
Tinned processed peas	170
Bilberries	150
Cocoa	150
Dates	100
Tinned gooseberries	100
Tinned cherries	100
Fresh pineapples	100
Black-currants	90
Dried figs	90
Bananas	80
Plain chocolate	75
Raspberries	70
Loganberries	70
Tinned pineapples	65
Grapes	50
Currants, dried	50
Sultanas	50
Raisins	50
Lentils	50

I.U. = International units.

[1] Carotene is converted into vitamin A in the body, but it is not so well utilized as vitamin A itself. It is customary to divide the carotene values by 3 in order to obtain the approximate 'vitamin A activity'.

[Compiled from results given in *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

SOURCES OF VITAMINS

VITAMIN B_1

	µg. per 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)
Wheat germ, processed	2,100
Edible food yeast	2,000
Cod roe	1,500
Peanuts	900
Soya flour, low fat and grits	870
Pork	720
Soya flour, full fat	660
Bacon, gammon, back, and streaky	600
Ham	600
Heart	600
Pork sausage meat, tinned	450
Luncheon meat, tinned	450
Corned pork, tinned	450
Oatmeal	450
Dried peas	450
Split peas	450
Haricot beans	450
Lentils	450
Green peas	420
Dried eggs	400
Liver, ox, calf, sheep, or pig	400
'Household' milk (dried skim)	390
Dried whole milk	300
Fat American bacon	300
Flour, 85 per cent. extraction, 1943 average	300
Walnuts	300
Tinned tongue	280
Tinned garden peas	250
Flour, 80 per cent. extraction, 1945 average	243
Almonds	240
Roasted peanuts	240
Kidney	240
Sheep's head	200
Shredded wheat	200
Bread (85 per cent. extraction)	185
Brown bread, 1943 average	183
Asparagus	180
Pork sausages	170
Mutton	160
Lamb	160
Oatmeal biscuits	160
Scones	160
Bread (80 per cent. extraction)	150
Fresh eggs	150
Beef sausages	150
Chicken	150
Duck	150
Plain cakes and buns	150
Water biscuits	130
Condensed milk, skim, sweetened	125
Potatoes	120
Watercress	120
Turnip tops	120
Brussels sprouts	120
Kale	120
Parsley	120
Parsnips	120
Tinned processed peas	120
Tinned salmon	120
Dehydrated meat	120
Pearl barley	120
Milk chocolate	120
Cocoa	120
Sponge cakes	120
Fruit cakes	110
Condensed milk, whole, sweetened	105
Meat pies	100
Sausage rolls	100
Leeks	100
Spinach	100
Cauliflower	100
Tinned asparagus	100
Mushrooms	90
Semolina	90
Plain chocolate	90
Doughnuts	85
Beef	80
Veal	80
Polished rice	80

SOURCES OF VITAMINS

VITAMIN B_1 (*continued*)

	μg. per 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)		*μg. per* 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)
Macaroni	75	Cherries	50
Spaghetti	75	Tinned pineapples	50
Lettuce	75	Fresh milk	45
Oranges	75	Apples	45
Pineapples	75	Black-currants	45
Runner beans	75	Red-currants	45
French beans	75	Greengages	45
Cabbage	75	Plums	45
Grapefruit	70	Gooseberries	45
Condensed milk, whole, unsweetened, U.K.	65	Tinned grapefruit	45
Condensed milk, whole, unsweetened, U.S.	55	Cucumber	45
Sweet biscuits	65	Marrow	45
Smoked haddock	60	Flaked wheat	40
White fish	60	Chocolate biscuits	35
Dried cod	60	Beetroot	35
Salt cod	60	Swedes	35
Carrots	60	Turnips	35
Endive	60	Cheese, Cheddar type	30
Radishes	60	Rabbit	30
Tomatoes	60	Apricots	30
Baked beans in tomato sauce	60	Grapes	30
Tinned tomatoes	50	Lemon juice	30
Damsons	50	Celery	30
Bananas	50	Onions	30
		Tinned carrots	30
		Tinned spinach	30
		Herring roe	30

The above foods are raw, unless otherwise stated. For notes on cooking losses, see p. 157.

[Compiled from results given in *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

SOURCES OF VITAMINS

RIBOFLAVIN

	Microgrammes per 100 gm. (3½ oz.) of food (edible portion)
Edible food yeast	5,000
Liver	3,000
'Household' milk (dried skim)	1,600
Dried eggs	1,300
Dried whole milk	1,150
Cheese	500
Condensed milk, skim, sweetened	430
Fresh eggs	400
Condensed milk, whole, sweetened	370
Condensed milk, whole, unsweetened, U.K.	370
Condensed milk, whole, unsweetened, U.S.	370
Dried peas, beans, and lentils	300
Lean meat	250
Flour, 85 per cent. extraction	200
Fresh milk, whole or skim	150
Fish	150
Potatoes, green and root vegetables	50
Fruit	30

[From *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

SOURCES OF VITAMINS

NICOTINIC ACID

	Mg. per 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)		*Mg. per* 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)
Edible food yeast	22–30	Shredded wheat	4·2
Wheat bran	25·0	Puffed wheat	4·2
Roasted peanuts	16·2	Ham	4·1
Peanut butter	16·2	Dried apricots	3·3
Liver	16·1	Pearl barley	3·1
Tinned tunny fish	10·6	Split peas	3·0
Chicken	8·6	Soya flour, low fat	2·9
Turkey	7·9	Corned beef, tinned	2·7
Heart	6·8	Luncheon meat, tinned	2·7
Tinned salmon	6·5	Cod	2·3
Veal, leg and chops	6·3	Soya flour, full fat	2·2
Wheat germ	6·0	Streaky bacon	2·1
Lamb, leg or chops	5·9	Macaroni and spaghetti	2·1
Flour, 100 per cent. extraction, Manitoba	5·5	Fresh green peas	2·1
Dried peaches	5·4	Dried prunes	1·7
Lamb, shoulder	5·2	Cornflakes	1·6
Tinned sardines (in oil)	5·2	White rice	1·4
Tongue	5·0	Flour, 85 per cent. extraction, Manitoba	1·3
Beef, ribs and steak	4·7	Potatoes	1·2
Liver sausage	4·6	Asparagus	1·2
Brown rice	4·6	Walnuts	1·2
Almonds	4·6	Oysters	1·2
Pork loin	4·4	Household milk (dried skim)	1·1
Beef for stewing	4·3	Oatmeal	1·1
Fish, miscellaneous (with 2·5 per cent. of fat)	4·2		

Unfortunately no comprehensive list of the nicotinic acid values of English foods is at present available. In the circumstances, recent American values have been used, except in a few cases.

[The value for edible food yeast was given to me by Dr. Kodicek in a private communication; that for wheat bran is from 'Nutrients in Wheat Endosperm', by T. Moran, *Nature*, 1945, vol. 155, p. 205; that for wheat germ from 'Bread', by R. A. McCance, *Lancet*, 1946 (i), p. 77; and the values for flour from 'The Chemical Composition of Wheat and Rye and of Flours derived therefrom', by R. A. McCance and others, *Biochemical Journal*, 1945, vol. 39, p. 213. All the other values are from *Tables of Food Composition in Terms of Eleven Nutrients*, U.S. Dept. of Agriculture, Misc. Publ. No. 572, 1945.]

SOURCES OF VITAMINS

VITAMIN C

	Average value in mg. per 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)
Fruit[1]	
Black-currants	200
Orange-juice concentrate, Ministry of Food	160
Rose-hip syrup, Ministry of Food	150
Peel from Seville oranges	86–190
,, sweet oranges	101
,, lemons	100
,, tangerines	69
,, Bramley's Seedling apples	9–77
Tinned black-currants	90
Black-currant purée	65
Strawberries	60
Oranges, sweet	55
Black-currant syrup, Ministry of Food	55
Lemon juice	50
Red-currants	45
Gooseberries	40
Grapefruit	40
Oranges, Seville	35
Raspberries	30
Loganberries	30
Tinned strawberries	25
Tinned grapefruit	25
Blackberries	20
Pineapple	20
Black-currant jam	20
Tinned gooseberries	18
Bilberries	15
Tinned raspberries	12
Tinned loganberries	12
Rhubarb	10
Bananas	10
Apricots	10
Peaches	10
Tinned pineapples	10
Apples	5
Cherries	5
Greengages	5
Damsons	5
Grapes	5
Tinned apricots	5
Tinned peaches	5
Plums	3
Pears	3
Tinned plums	2
Tinned pears	1

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[1] Stewing destroys little or no vitamin C.

SOURCES OF VITAMINS

VITAMIN C (*continued*)

	Average value in mg. per 100 gm. (3½ oz.) of food (edible portion)		*Average value in mg. per 100 gm. (3½ oz.) of food (edible portion)*
Vegetables[1] *for salads and for cooking*			
Nasturtium leaves	200–465	Tinned asparagus	30
Nasturtium stems	100–160	Tomatoes	25
Parsley	150	Turnips	25
Kale	130	Tinned spinach	25
Horse-radish	130	Spring onions	20
Brussels sprouts	100	Leeks	20
Turnip tops	100	Endive	20
Cabbage	70	Runner beans	20
Cauliflower	70	Tinned swedes	20
Spinach	65	Lettuce	15
Watercress	60	Tinned garden peas	15
Asparagus	60	Tinned tomatoes	15
Swedes	40	Cucumber	10
Mustard and cress	37	Beetroot	10
Potatoes:		French beans	10
early	30	Carrots	10
main crop before Oct.	30	Onions	10
Oct. and Nov.	20	Parsnips	10
Dec.	15	Marrow	5
Jan. and Feb.	10	Celery	5
March and onwards	7	Tinned carrots	5
Green peas	30	Baked beans in tomato sauce	3
Broad beans	30		
Radishes	30		

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[1] For the effect of cooking, see p. 157.

[The values for peel are from 'The Ascorbic Acid Content of Certain Citrous Fruits and Some Manufactured Products', by A. L. Bacharach and others, *Biochemical Journal*, 1934, vol. 28, p. 1038; the value for mustard and cress is from 'Ascorbic Acid Values of Fruits and Vegetables for Dietary Surveys', by M. Olliver, *Chemistry and Industry*, 1943, vol. 62, p. 146; the values for nasturtiums are from 'Vitamin C in plants: Nasturtium', by M. D. Sutherland, *Nature*, 1944, vol. 153, p. 683; and the rest are from *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

SOURCES OF VITAMINS

VITAMIN D

	I.U. per 100 *gm.* (3½ *oz.*) *of food* (*edible portion*)
Halibut-liver oil, average	245,000
Cod-liver oil (Ministry of Food)	20,000
Tinned sardines	1,000
Herrings, fresh or cured	850
Mackerel	700
Tinned salmon	600
Dried eggs	240
Vitaminized margarine	200
Tinned herrings	170
Fresh eggs	60
Empire butter	60
Dripping	30
Cheese	15
Dried whole milk	10
Condensed milk, whole, unsweetened	3·5
Condensed milk, whole, sweetened	2·6
Fresh milk	1·0

I.U. = International units

[The value for halibut-liver oil is from *The Biological Standardisation of the Vitamins*, by K. H. Coward (Baillière, Tindall, & Cox), 1938; and all the other values from *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945.]

TABLES SHOWING THE COMPOSITION OF FOODS IN TERMS OF PROTEIN, FAT, CARBOHYDRATE, CALORIES, CALCIUM, IRON, VITAMIN A, VITAMIN B_1, RIBOFLAVIN, NICOTINIC ACID, VITAMIN C, AND VITAMIN D

The values in the following tables all refer to one ounce of the edible portion of the food.

I.U. = International units
μg. = microgrammes = 0·001 mg.
Tr. = trace
0 = none present
— = substance may be present or absent; no data available in the tables consulted (see below).

The values for protein, fat, carbohydrate, calories, calcium, and iron are from *The Chemical Composition of Foods*, by R. A. McCance and E. M. Widdowson (H.M. Stationery Office), 1946. The carbohydrate values are for available carbohydrate only, expressed as monosaccharide.

The values for vitamins A, B_1, C, D, and riboflavin have been calculated from the values per 100 gm. of food (edible portion) given in *Nutritive Values of Wartime Foods* (H.M. Stationery Office), 1945, and those for nicotinic acid have been calculated from values per 100 gm. in *Tables of Food Composition in Terms of Eleven Nutrients*, U.S. Dept. of Agriculture, Misc. Publ. No. 572, 1945 (see footnote on p. 153). Since the vitamin values refer to uncooked foods, the following notes are given on the effect of cooking on the various vitamins, so that due allowance can be made when the tables are used.

Effect of Cooking on Vitamins

Vitamins A and D. These remain unaffected by cooking.

Vitamin B_1, riboflavin, and nicotinic acid. These vitamins are all soluble in water and tend to diffuse out of foods when they are cooked in water. Only about 10 per cent. of the riboflavin of food appears to be lost during cooking, and even less of the nicotinic acid. But there is usually a loss of vitamin B_1. In meat, this amounts to about 50 per cent. with roasting and grilling, and about 20 per cent. with boiling, stewing, and frying. In vegetables, about 35 per cent. of the vitamin B_1 is lost during cooking, and the addition of cooking-soda leads to increased destruction. The loss during bread-making is about 15 per cent., in cake-making about 25 per cent., and in the baking of biscuits about 60 per cent.

Vitamin C. There is little or no destruction when fruit is stewed, but there is a good deal of diffusion into the surrounding fluid. In vegetables there is also diffusion out of the food, and there may be considerable destruction as well. The extent of the loss depends on the method of cooking used. With ordinary domestic boiling, about half the vitamin C is lost with potatoes and about two thirds or more with green vegetables. Frying is less destructive, but steaming is worse. Pressure-cooking causes considerable loss, and hay-box cooking is the worst method from this point of view. With green vegetables, 'conservative' cooking leads to the least possible loss (see p. 98).

MEAT, POULTRY, AND GAME

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin A	Vitamin B_1[1]	Riboflavin[1]	Nicotinic acid[1]	Vitamin C	Vitamin D
	gm. per oz.			per oz.	mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Bacon, streaky, fried	6·8	13·1	0	149	14·9	0·91	0	170	71	0·6	0	—
Bacon, gammon, fried	8·9	9·6	0	126	7·1	0·80	0	170	71	—	0	—
Beef, corned	6·3	4·3	0	66	3·6	2·78	0	0	—	0·8	0	—
Beef-steak, grilled	7·2	6·1	0	86	2·6	1·48	14	23	71	1·3	0	—
Beef-steak, stewed, lean only	8·7	2·4	0	58	0·9	1·45	—	23	71	1·2	0	—
Beef, topside, roast, lean only	7·6	4·3	0	71	1·8	1·34	—	23	71	1·3	0	—
Beef, topside, roast, fat only	1·1	26·9	0	255	1·0	0·43	—	—	—	—	0	—
Brain, calf, boiled	3·4	1·6	0	29	4·6	0·57	—	—	—	—	0	—
Chicken, boiled	7·4	2·9	0	58	3·0	0·60	0	42	71	2·4	0	—
Chicken, roast	8·4	2·1	0	54	4·1	0·74	0	42	71	2·4	0	—
Duck, roast	6·5	6·7	0	89	5·4	1·64	0	42	71	—	0	—
Goose, roast	8·0	6·4	0	92	3·0	1·32	—	—	71	—	0	—
Ham, boiled, lean only	6·6	3·8	0	62	4·8	0·74	0	170	71	1·2	0	—
Ham, boiled, fat only	0·8	26·1	0	246	0·9	0·62	0	—	—	—	0	—
Ham or pork, chopped, tinned	4·3	8·5	Tr.	97	3·4	0·44	0	—	—	—	0	—
Hare, stewed	8·3	2·3	0	55	5·9	3·07	—	—	71	—	0	—
Heart, sheep, roast	7·1	4·2	0	68	2·7	2·30	57	170	—	1·9	—	—
Kidney, ox, stewed	7·3	1·6	0	45	5·9	2·02	283	68	—	—	—	—
Kidney, sheep, fried	7·9	2·6	0	57	4·7	4·12	283	68	—	—	—	—

Liver, ox, covered with flour and fried	8·4	4·5	1·1	81	2·4	5·89	4,252	113	850	4·6	—	—
Meat paste	5·6	3·6	1·2	61	7·5	1·05	—	—	—	—	—	—
Mutton chops, grilled, lean only	7·5	5·0	0	77	5·9	0·71	—	45	71	1·7	0	—
Mutton chops, grilled, fat only	2·6	25·5	0	248	3·6	0·62	—	—	—	—	0	—
Mutton, leg, roast	7·1	5·8	0	83	1·2	1·22	14	45	71	1·7	0	—
Mutton, neck, stewed	6·9	6·9	0	92	14·2	1·93	14	45	71	1·7	0	—
Pheasant, roast	8·8	2·6	0	61	14·0	2·38	—	—	71	—	0	—
Pork, leg, roast	7·0	6·6	0	90	1·5	0·48	0	204	71	1·2	0	—
Pork, loin, roast	5·5	11·5	0	129	2·1	0·65	0	204	71	1·2	0	—
Rabbit, stewed	7·6	2·2	0	51	3·2	0·54	0	8	71	—	0	—
Sausage, beef, fried	3·9	5·2	4·5	81	6·0	1·16	3	42	—	—	0	—
Sausage, pork, fried	3·3	7·1	3·6	93	5·6	0·94	0	48	—	—	0	—
Sweetbread, stewed	6·4	2·6	0	51	4·1	0·46	—	—	—	—	0	—
Tongue, ox, pickled, boiled	5·4	6·8	0·7	88	8·8	0·85	0	79	—	1·4	0	—
Tripe, stewed	5·1	0·9	0	29	36·0	0·45	—	—	—	—	0	—
Turkey, roast	8·6	2·2	0	56	10·9	1·08	—	—	71	2·2	0	—
Veal, roast	8·7	3·3	0	66	4·1	1·22	14	23	71	1·8	0	—
Venison, roast	9·5	1·8	0	56	8·2	2·22	—	—	71	—	0	—

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[1] These values refer to uncooked foods (see note on p. 157).

FISH AND SHELL-FISH

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin		Riboflavin[1]	Nicotinic acid[1]	Vitamin	
							A	B_1[1]			C	D
	gm. per oz.			per oz.	mg. per oz.		I.U. per oz.	μg. per oz.		mg. per oz.		I.U. per oz.
Bloaters, grilled	6·4	4·9	0	73	35·0	0·62	45	3	43	—	0	241
Cod, coated with batter and crumbs, fried	5·9	1·3	0·8	40	14·1	0·28	0	17	43	0·7	0	—
Cod, steamed	5·1	0·3	0	23	4·2	0·14	0	17	43	0·7	0	—
Cod, salt, boiled	9·1	0·3	0	40	6·4	0·51	0	17	—	—	0	—
Cod-roe, fried	5·8	3·4	0·9	59	4·8	0·45	—	425	—	—	0	—
Crab, boiled	5·4	1·5	0	36	8·3	0·37	—	—	—	—	0	—
Eels, silver, stewed	5·0	9·2	0	106	4·1	0·28	0	17	43	—	0	—
Fish paste	4·2	2·7	1·9	49	41·5	1·70	—	—	—	—	0	—
Haddock, coated with batter and crumbs, fried	5·8	2·4	1·0	50	32·4	0·34	0	17	43	—	0	—
Haddock, steamed	6·2	0·2	0	28	15·5	0·20	0	17	43	—	0	—
Haddock (smoked), steamed	6·3	0·3	0	28	16·3	0·28	0	—	—	—	0	—
Hake, coated with batter and crumbs, fried	5·5	3·2	1·5	58	7·3	0·26	0	17	43	—	0	—
Hake, steamed	5·2	0·9	0	30	4·5	0·17	0	17	43	—	0	—
Halibut, steamed	6·4	1·1	0	37	3·7	0·17	0	17	43	—	0	—
Herrings, baked in vinegar	4·8	3·7	0	54	16·6	0·45	43	—	43	—	0	241
Herrings, coated with oatmeal, fried	6·2	4·3	0·4	67	11·0	0·54	43	3	43	—	0	241

Kippers, baked	6·6	3·2	0	57	18·4	0·40	51	3	43	—	0	241
Lemon sole, coated with batter and crumbs, fried	4·4	3·7	2·6	62	26·9	0·31	0	17	43	—	0	—
Lemon sole, steamed	5·6	0·3	0	26	6·3	0·17	0	17	43	—	0	—
Lobster, boiled	6·0	1·0	0	34	17·5	0·23	—	—	—	—	0	—
Mackerel, coated with oatmeal, fried	5·7	3·2	0	53	8·1	0·34	0	17	43	—	0	198
Oysters, raw	2·9	0·3	Tr.	14	52·9	1·70	—	—	—	0·3	—	—
Pilchards, tinned	6·2	3·1	0	54	65·8	0·88	0	—	43	—	0	—
Plaice, coated with batter and crumbs, fried	5·1	4·1	2·0	66	12·7	0·23	0	17	43	—	0	—
Plaice, steamed	5·1	0·5	0	26	10·7	0·17	0	17	43	—	0	—
Salmon, steamed	5·4	3·7	0	57	8·2	0·23	0	17	43	—	0	—
Salmon, tinned	5·6	1·7	0	39	18·8	0·37	71	34	43	1·8	0	170
Sardines, tinned, in oil	5·8	6·4	0	84	116·0	1·13	77	—	43	1·5	0	283
Sole, coated with batter and crumbs, fried	5·7	5·2	1·5	78	37·2	0·40	0	17	43	—	0	—
Sole, steamed	5·0	0·4	0	24	32·1	0·20	0	17	43	—	0	—
Sprats, fried	6·3	10·8	0	126	201·0	1·28	—	—	43	—	0	—
Whitebait, coated with flour, fried	5·2	13·5	1·5	152	244·0	1·45	—	—	43	—	0	—
Whiting, coated with batter and crumbs, fried	4·9	2·9	2·0	55	13·6	0·20	0	17	43	—	0	—
Whiting, steamed	5·7	0·3	0	26	11·9	0·28	0	17	43	—	0	—

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[1] These values refer to uncooked foods (see note on p. 157).

VEGETABLES

	Protein	Fat	Carbohydrate	Calories per oz.	Calcium	Iron	Vitamin		Riboflavin[2]	Nicotinic acid[2]	Vitamin	
							A[1]	B$_1$[2]			C[2]	D
	gm. per oz.				mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Artichokes, boiled	0·5	Tr.	0·9[3]	5	8·6	0·12	—	—	14	—	—	0
Asparagus, boiled	1·0	Tr.	0·3	5	7·3	0·25	198	51	—	0·3	17	0
Beans, baked, tinned	1·7	0·1	4·9	26	17·4	0·58	142	17	—	—	1	0
Beans, broad, boiled	1·2	Tr.	2·0	12	6·0	0·28	—	—	14	—	8	0
Beans, haricot, boiled	1·9	Tr.	4·7	25	18·3	0·71	0	128	85	—	0	0
Beans, runner, boiled	0·2	Tr.	0·3	2	7·3	0·17	170	21	14	—	6	0
Beetroot, boiled	0·5	Tr.	2·8	13	8·5	0·20	0	10	14	0·1	3	0
Brussels sprouts, boiled	0·7	Tr.	0·5	5	7·7	0·18	113	34	14	0·1	28	0
Cabbage, spring, boiled	0·3	Tr.	0·2	2	8·5	0·13	255	21	14	0·1	20	0
Cabbage, winter, boiled	0·2	Tr.	0·4	3	16·6	0·13	255	21	14	0·1	20	0
Carrots, old, boiled	0·2	Tr.	1·2	5	10·4	0·11	5,672	17	14	0·1	3	0
Carrots, young, boiled	0·3	Tr.	1·3	6	8·2	0·12	2,836	17	14	0·1	3	0
Cauliflower, boiled	0·4	Tr.	0·3	3	6·5	0·14	0	28	14	0·2	20	0
Celery, raw	0·3	Tr.	0·4	3	14·8	0·17	0	9	—	0·1	1	0
Celery, boiled	0·2	Tr.	0·2	1	14·8	0·12	0	9	—	0·1	1	0
Cucumber, raw	0·2	Tr.	0·5	3	6·5	0·09	0	13	—	Tr.	3	0
Horse-radish, raw	1·3	Tr.	3·1	17	33·8	0·58	—	—	—	—	37	0
Leeks, boiled	0·5	Tr.	1·3	7	17·2	0·57	198	28	—	—	6	0
Lentils, boiled	1·9	Tr.	5·2	27	3·0	0·63	14	128	85	—	0	0

Lettuce, raw	0·3	Tr.	0·5	3	7·4	0·21	1,134	21	14	Tr.	4	0
Marrow, boiled	0·1	Tr.	0·4	2	3·9	0·06	9	13	—	—	1	0
Mushrooms, fried	0·6	6·4	0	62	1·0	0·36	—	26	—	—	0	0
Mustard and cress	0·5	Tr.	0·3	3	18·7	1·29	—	—	14	—	10	0
Onions, boiled	0·2	Tr.	0·8	4	6·9	0·07	0	9	—	Tr.	3	0
Onions, fried	0·5	9·5	2·9	101	17·4	0·17	0	9	—	Tr.	3	0
Onions, spring, raw	0·3	Tr.	2·4	10	38·4	0·35	198	6	—	—		0
Parsley	1·5	Tr.	Tr.	6	92·2	2·27	3,685	34	14	—	42	0
Parsnips, boiled	0·4	Tr.	3·8	16	10·1	0·13	57	34	14	Tr.	3	0
Peas, fresh, boiled	1·4	Tr.	2·2	14	3·6	0·35	142	119	—	0·6	8	0
Peas, dried, boiled	2·0	Tr.	5·4	28	6·9	0·41	57	128	85	0·9	0	0
Peas, garden, tinned	1·7	Tr.	4·7	24	7·3	0·53	142	71	—	0·3	4	0
Potatoes, new boiled	0·5	Tr.	5·2	21	1·4	0·13	0	34	14	0·3	8	0
Potatoes, old, baked in skins	0·7	Tr.	7·1	30	2·6	0·25	0	34	14	0·3	2–6[4]	0
Potatoes, old, boiled	0·4	Tr.	5·6	23	1·2	0·14	0	34	14	0·3	2–6[4]	0
Potatoes, fried chipped	1·1	2·6	10·6	68	3·9	0·38	0	34	14	0·3	2–6[4]	0
Potatoes, roast	0·8	0·3	7·8	35	2·9	0·28	0	34	14	0·3	2–6[4]	0
Radishes	0·3	Tr.	0·8	4	12·4	0·54	0	17	14	Tr.	8	0
Spinach, cooked	1·4	Tr.	0·4	7	169·0[5]	1·14	3,685	28	14	0·2	18	0
Swedes, boiled	0·3	Tr.	1·1	5	11·8	0·08	0	10	14	—	11	0
Tomatoes, raw	0·3	Tr.	0·8	4	3·8	0·12	850	17	—	0·2	7	0
Tomatoes, fried	0·3	1·7	0·9	20	4·4	0·14	850	17	—	0·2	7	0
Turnips, boiled	0·2	Tr.	0·7	3	15·6	0·10	0	10	14	0·1	7	0
Watercress	0·8	Tr.	0·2	4	63·0	0·46	1,417	34	14	—	17	0

[1] As carotene. To obtain the 'vitamin A activity', divide by 3.
[2] These values refer to uncooked foods (see note on p. 157).
[3] This is inulin, which is partially unavailable.
[4] This varies according to the period of storage, see Fig. 7, p. 97.
[5] This may be unavailable, since oxalic acid is also present.

FRESH FRUIT, STEWED FRUIT,[1] AND TINNED FRUIT

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin		Riboflavin	Nicotinic acid	Vitamin	
							A[2]	B_1			C	D
	gm. per oz.			per oz.	mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Apples, eating	0·1	Tr.	3·5	13	1·0	0·08	11	13	9	Tr.	1	0
Apples, cooking	0·1	Tr.	2·7	10	1·0	0·08	11	13	9	Tr.	1	0
Apricots, fresh	0·2	Tr.	1·9	8	4·9	0·11	213	8	9	0·2	3	0
Apricots, tinned, in syrup	0·1	Tr.	4·5	17	3·4	0·20	142	6	9	0·1	1	0
Bananas	0·3	Tr.	5·5	22	1·9	0·12	23	14	9	0·2	3	0
Blackberries	0·4	Tr.	1·8	8	18·0	0·24	85	6	9	—	6	0
Black-currants	0·3	Tr.	1·9	8	17·2	0·36	26	13	9	—	57	0
Cherries, eating	0·2	Tr.	3·4	13	4·5	0·11	57	14	9	—	1	0
Cherries, cooking	0·2	Tr.	3·3	13	5·7	0·09	57	14	9	—	1	0
Damsons	0·1	Tr.	2·7	11	6·7	0·12	—	14	9	—	1	0
Fruit salad, tinned, in syrup	0·1	Tr.	5·3	20	2·4	0·98	—	—	9	0·1	—	0
Gooseberries, green	0·3	Tr.	1·0	5	8·0	0·09	57	13	9	—	11	0
Gooseberries, ripe	0·2	Tr.	2·6	10	5·2	0·16	57	13	9	—	11	0
Grapes	0·2	Tr.	4·6	18	5·4	0·10	14	8	9	0·1	1	0
Grapefruit, fresh	0·2	Tr.	1·5	6	4·9	0·07	6	20	9	Tr.	11	0
Greengages	0·2	Tr.	3·4	14	4·8	0·11	113	13	9	—	1	0
Lemon juice	0·1	Tr.	0·5	2	2·4	0·04	0	8	—	—	14	0

Loganberries	0·3	Tr.	1·0	5	10·0	0·39	20	6	9	—	8	0
Loganberries, tinned, in syrup	0·2	Tr.	7·4	29	5·0	0·82	10	3	9	—	3	0
Melon, Cantaloupe	0·3	Tr.	1·5	7	5·4	0·23	—	—	9	0·2	—	0
Melon, yellow	0·2	Tr.	1·4	6	3·9	0·07	—	—	9	—	—	0
Olives (in brine)	0·3	3·1	0	30	17·4	0·29	—	—	—	—	—	0
Oranges	0·2	Tr.	2·4	10	11·7	0·09	85	21	9	Tr.	16	0
Peaches, fresh	0·2	Tr.	2·6	11	1·4	0·11	213	6	9	0·3	3	0
Peaches, tinned, in syrup	0·1	Tr.	4·9	19	1·0	0·55	142	3	9	0·2	1	0
Pears, eating	0·1	Tr.	3·0	11	2·0	0·06	3	6	9	Tr.	1	0
Pears, cooking	0·1	Tr.	2·6	10	2·0	0·05	3	6	9	Tr.	1	0
Pears, tinned, in syrup	0·1	Tr.	4·7	18	1·5	0·50	1	3	9	Tr.	Tr.	0
Pineapples, fresh	0·1	Tr.	3·3	13	3·5	0·12	28	21	9	Tr.	6	0
Pineapples, tinned, in syrup	0·1	Tr.	4·7	18	3·8	0·48	18	14	9	Tr.	3	0
Plums, eating	0·2	Tr.	2·7	11	3·1	0·10	113	13	9	0·2	1	0
Plums, cooking	0·2	Tr.	1·8	7	3·9	0·09	113	13	9	0·2	1	0
Raspberries, fresh	0·3	Tr.	1·6	7	11·6	0·34	20	6	9	—	8	0
Red-currants	0·3	Tr.	1·2	6	10·2	0·35	7	13	9	—	13	0
Rhubarb	0·2	Tr.	0·3	2	29·2	0·11	0	6	—	Tr.	3	0
Strawberries	0·2	Tr.	1·8	7	6·3	0·20	4	6	9	0·1	17	0
Tangerines	0·3	Tr.	2·3	10	11·8	0·08	—	—	9	Tr.	—	0

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[1] *Stewed fruit.* Approximate values for the composition of an ounce of unsweetened stewed fruit can be obtained by taking half the values given for raw fruits.

[2] As carotene. To obtain the 'vitamin A activity', divide by 3.

DRIED FRUIT

	Protein	Fat	Carbohydrate	Calories per oz.	Calcium	Iron	Vitamin		Riboflavin	Nicotinic acid	Vitamin	
							A[1]	B_1			*C*	*D*
	gm. per oz.				*mg. per oz.*		*I.U. per oz.*	*µg. per oz.*		*mg. per oz.*		*I.U. per oz.*
Apricots	1·4	Tr.	12·3	52	26·3	1·16	1,417	0	—	0·9	0	0
Currants	0·5	Tr.	18·0	69	27·1	0·52	14	0	—	—	0	0
Dates	0·6	Tr.	18·1	70	19·2	0·46	28	0	—	—	0	0
Figs	1·0	Tr.	15·0	61	80·5	1·18	26	0	—	—	0	0
Peaches	1·0	Tr.	15·0	61	10·1	1·92	—	0	—	1·5	0	0
Prunes	0·7	Tr.	11·4	46	10·7	0·82	709	0	—	0·5	0	0
Raisins	0·3	Tr.	18·3	70	17·2	0·44	14	0	—	0·1	0	0
Sultanas	0·5	Tr.	18·4	71	14·9	0·52	14	0	—	—	0	0
NUTS												
Almonds	5·8	15·2	1·2	170	70·0	1·20	0	68	—	1·3	0	0
Barcelona nuts	3·7	18·2	1·5	189	48·2	0·84	0	—	—	—	0	0
Brazil nuts	3·9	17·3	1·2	183	50·0	0·80	0	—	—	—	0	0
Chestnuts	0·7	0·8	10·4	49	13·1	0·25	0	—	—	—	0	0
Cobnuts	2·6	10·2	1·9	113	12·5	0·30	0	—	—	—	0	0
Coconut, fresh	1·1	10·2	1·1	104	3·7	0·59	0	—	—	—	0	0
Coconut, desiccated	1·9	17·6	1·8	178	6·4	1·02	0	—	—	—	0	0
Peanuts, raw	8·0	13·9	2·4	171	17·3	0·58	0	255	—	—	0	0
Peanuts, roasted	8·0	13·9	2·4	171	17·3	0·58	0	68	—	4·6	0	0
Walnuts	3·6	14·6	1·4	156	17·3	0·67	0	85	—	0·3	0	0

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[1] As carotene. To obtain the 'vitamin A activity', divide by 3.

EGGS, MILK, CHEESE, BUTTER, AND OTHER FATS

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin		Riboflavin	Nicotinic acid	Vitamin	
							A	B_1			C	D
	gm. per oz.			per oz.	mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Butter	0·1	24·2	Tr.	226	4·2	0·05	1,136	0	—	Tr.	0	17
Cheese, Cheddar	7·1	9·8	Tr.	120	230·0	0·16	369	9	142	0·1	0	4
Cheese, cream	0·9	24·5	Tr.	232	8·4	0·04	—	—	—	—	0	—
Cheese, rindless	6·4	8·5	Tr.	106	205·0	0·16	—	—	—	—	0	—
Cream	0·5	11·9	0·7	115	16·8	0·07	—	—	—	Tr.	—	—
Dripping, beef	Tr.	28·1	0	262	0·2	0·06	28	0	—	—	0	8
Eggs, raw or boiled (*1 egg weighs 2 oz.*)	3·4	3·5	0	46	15·9	0·72	283	43	113	Tr.	0	17
Eggs, fried	4·0	5·5	0	68	18·2	0·72	283	43	113	Tr.	0	17
Eggs, poached	3·5	3·3	0	45	14·7	0·65	283	43	113	Tr.	0	17
Eggs, dried	12·3	12·3	0	165	54·0	2·23	852	114	369	0·1	0	68
Margarine, vitaminized	0·1	24·2	0	226	1·2	0·09	568	0	—	0	0	57
Milk (*1 pint weighs 20 oz.*)	0·9	1·1	1·4	19	34·1	0·02	20–40	13	43	Tr.	Tr.[1]	Tr.
Milk, skim	1·0	0·1	1·4	10	35·2	0·02	0	13	—	Tr.	Tr.	0
Milk, condensed, skim, sweetened	2·8	0·1	17·0	76	109·0	0·08	6	36	122	—	1	0
Milk, condensed, whole, sweetened	2·3	3·4	15·9	100	97·5	0·05	105	30	105	0·1	1	1
Milk, condensed, whole unsweetened	2·2	2·4	3·5	44	82·5	0·05	105	18	105	0·1	1	1
Milk, dried, whole	7·5	8·4	11·0	150	272·0	0·18	304	85	326	0·2	2	3
Milk, dried, skim 'household'	9·7	0·1	14·0	93	359·0	0·15	9	111	454	0·3	2	0
Suet	0·3	28·1	0	262	1·7	0·11	—	—	—	—	0	—

[1] As delivered.

BREAD, FLOUR, CEREALS, ETC.

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin		Riboflavin	Nicotinic acid	Vitamin	
							A	B_1			C	D
	gm. per oz.			per oz.	mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Bread, brown (90%)	2·4	0·4	15·2	70	4·9	0·57	0	52	—	—	0	0
Bread (85%), fortified	2·4	0·3	15·8	72	17·3	0·52	0	53	—	—	0	0
Bread (80%), fortified	2·4	0·3	16·3	74	16·8	0·45	0	42	—	—	0	0
Bread, white (70%)	2·3	0·2	16·9	75	3·2	0·41	0	—	—	—	0	0
Cornflour	0·1	0·2	26·2	100	4·4	0·41	0	0	0	0	0	0
Flour, brown (90%)	3·3	0·5	21·1	98	6·8	0·80	0	—	—	—	0	0
Flour (85%), fortified	3·3	0·5	21·6	99	23·9	0·71	0	85	57	0·4	0	0
Flour (80%), fortified	3·2	0·4	22·1	100	23·1	0·61	0	69	—	0·3	0	0
Flour, white (70%)	3·1	0·3	22·4	100	4·3	0·54	0	—	—	0·2	0	0
Grapenuts	3·3	0·9	21·4	102	13·6	1·60	—	—	—	—	0	0
Macaroni	3·3	0·4	22·1	100	5·8	0·37	0	21	—	0·6	0	0
Oatmeal or rolled oats	3·4	2·5	20·6	115	15·8	1·17	0	128	—	0·3	0	0
Pearl barley	2·2	0·5	23·7	102	2·8	0·19	0	34	—	0·9	0	0
Post toasties	1·9	0·2	25·2	104	1·3	0·47	—	—	—	—	0	0
Rice, polished	1·8	0·3	24·6	102	1·1	0·13	0	23	—	0·4	0	0
Sago	0·1	0·1	26·7	101	2·8	0·34	0	0	—	—	0	0
Semolina	3·0	0·5	22·0	100	5·2	0·30	0	26	—	—	0	0
Shredded wheat	2·8	0·8	22·4	103	9·9	1·27	0	57	—	1·2	0	0
Soya flour, full fat	11·5	6·7	3·8	123	59·3	1·97	0	187	—	0·6	0	0
Soya flour, low fat and grits	14·1	2·0	4·9	95	68·5	2·60	0	247	—	0·8	0	0
Tapioca	0·1	Tr.	27·0	102	2·3	0·09	0	0	0	0	0	0

BISCUITS, CAKES, PASTRY, PUDDINGS, ETC.

	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin		Riboflavin	Nicotinic acid	Vitamin	
							A	B₁			C	D
	gm. per oz.			Calories per oz.	mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Biscuits, oatmeal	2·5	6·8	17·7	143	10·2	0·61	0	45	—	—	0	0
Biscuits, sweet	1·6	8·7	18·9	158	7·7	0·24	0	18	—	—	0	0
Biscuits, water	3·0	3·5	20·7	126	6·3	0·27	0	37	—	—	0	0
Blancmange	0·9	1·1	5·3	34	33·1	0·05	—	—	—	—	0	0
Buns, plain	2·5	1·7	16·2	87	23·0	0·77	—	43	—	—	0	0
Cake, fruit	1·9	3·1	14·6	91	19·0	0·69	77	31	—	—	0	0
Cake, sponge	2·5	2·0	15·6	88	9·9	0·46	85	34	—	—	0	0
Custard (egg), baked	1·5	1·7	2·8	32	36·1	0·14	—	—	—	—	0	—
Custard (egg), boiled	1·3	1·5	3·8	34	32·1	0·13	—	—	—	—	0	—
Custard (powder), boiled	0·9	1·1	5·0	33	34·7	0·04	—	—	—	—	0	0
Jelly	0·6	0	5·4	22	2·7	0·15	—	—	—	—	0	0
Pastry, puff	1·5	10·2	12·4	147	3·3	0·18	—	—	—	—	0	0
Pastry, short	1·9	8·6	15·5	146	4·0	0·21	—	—	—	—	0	0
Sausage roll	2·3	8·8	11·4	134	4·3	0·41	0	28	—	—	0	0
Scones	2·2	3·8	16·3	106	17·9	0·19	—	—	—	—	0	0
Semolina pudding	1·2	1·1	5·7	37	34·0	0·06	—	—	—	—	0	0
Steak and kidney pie	4·4	5·4	4·8	85	2·9	1·58	0	28	—	—	0	0
Suet pudding	1·1	5·1	10·6	92	12·7	0·12	—	—	—	—	0	—
Swiss roll	1·5	0·7	16·3	74	20·0	0·72	—	—	—	—	0	0
Yorkshire pudding	2·0	2·7	7·7	62	28·7	0·19	—	—	—	—	0	—

SUGAR, JAM, AND MISCELLANEOUS

	Protein	Fat	Carbohydrate	Calories per oz.	Calcium	Iron	Vitamin A[1]	Vitamin B₁	Riboflavin	Nicotinic acid	Vitamin C	Vitamin D
	gm. per oz.				mg. per oz.		I.U. per oz.	µg. per oz.		mg. per oz.		I.U. per oz.
Black-currant purée	0·1	Tr.	11·4	43	9·7	0·45	—	—	—	—	18	0
Chocolate, milk	2·5	10·7	15·5	167	69·9	0·49	—	34	—	—	0	0
Chocolate, plain	1·6	10·0	14·9	155	17·9	0·82	21	26	—	—	0	0
Cocoa powder	5·8	6·6	9·9	128	14·6	4·06	43	34	—	0·7	0	0
Curry powder	2·7	3·1	7·4	67	181·0	21·30	—	—	—	—	0	0
Golden syrup	0·1	0	22·4	84	7·5	0·41	0	0	—	—	0	0
Honey	0·1	Tr.	21·7	82	1·5	0·11	0	0	—	Tr.	0	0
Jam, blackberry	0·2	0	19·6	74	6·9	0·42	6	Tr.	—	Tr.	1	0
Jam, black-currant	0·2	0	19·6	74	6·9	0·42	6	Tr.	—	Tr.	6	0
Jam, gooseberry	0·2	0	19·6	74	6·9	0·42	6	Tr.	—	Tr.	1	0
Jam, plum	0·1	0	19·7	74	3·4	0·29	6	Tr.	—	Tr.	Tr.	0
Jam, raspberry	0·2	0	19·6	74	6·9	0·42	6	Tr.	—	Tr.	1	0
Jam, strawberry	0·2	0	19·6	74	6·9	0·42	6	Tr.	—	Tr.	1	0
Marmalade	Tr.	0	19·8	74	9·9	0·16	—	Tr.	—	Tr.	2	0
Salad cream	0·8	8·3	2·6	91	—	—	—	—	—	—	0	—
Sugar	Tr.	0	29·7	112	0·4	0·01	0	0	0	0	0	0
Treacle, black	0·3	0	19·1	73	140·5	2·60	0	—	—	—	0	0
Yeast, edible, food	12·2	0·7	0·9	59	36·0	5·70	0	568	1,417	6–8	0	—

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[1] As carotene. To obtain the 'vitamin A activity', divide by 3.

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